The lake-dwelling phenomenon

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FORMATION AND DEFORMATION PROCESSES

Katia F. ACHINO

1. INTRODUCTION: DIVERSITY AND VARIETY OF WETLAND ARCHAEOLOGY

Humans have always been fascinated by water regardless of its forms, either as sea, rivers, lakes or simple marshy ponds (Pétrequin 1984: 30-31). We have been linked to these features, in a way or another, since the dawn of humanity. Indeed, a large number of well-known early hominid sites occurred in wetland environments: in Europe sites of the Early Palaeolithic such as Torralba in Spain, Boxgrove in England and Bilzingsleben in Germany are associated with wetlands (Coles 2004b: 183–184).

Swamps, *playas*, marshes and bottomlands have been among most attractive areas on the landscape during the prehistory, because of their resource diversity, productivity and reliability (Forman & Godron 1986; Niering 1985: 29; Nicholas 1988: 268–269; Nicholas 2003: 262). Different needs (as subsistence, in terms of food procurement through water and primary resources) and sheer necessity (such as defence), or more elaborated socio-economic aspects (such as logistic reasons, linked to settlements) or beliefs (Menotti 2012: 27; Menotti & O'Sullivan 2013: 31) might have probably driven the interaction between people and wetland.

It is difficult to estimate exactly when this relationship started to become more systematic: however, people probably began to settle into humid environments and to fully connect their everyday-lives to that particular ecosystem in relatively recent times. Although we are aware of sporadic episodes of wetland occupation and exploitation in the Holocene, particularly in the Mesolithic, such as at Starr Carr, in England (Clark 1954; Coles 2004a; Milner et al. 2018a; Milner et al. 2018b), a few sites on Feder Lake, in southern Germany (Schlichtherle 2004) and some cases in Lithuania (Menotti et al. 2005), the large-scale settling of lacustrine environments did not occur until the Neolithic (Menotti 2004: 2).

As time elapses, people-wetland interaction becomes more and more complex: it encompasses elements both sacred and profane (Menotti & O'Sullivan 2013: 29), such as the "bog bodies" (Menotti 2004: 11), a widespread variety of objects, as war booties at Skedemosse, Sweden (Larsson 1998; Menotti 2012: 16) and the openset proposed by Jennings (2014: 117–129).

Furthermore, this environment could own manifold benefits, as the presence of harvesting resource and the opportunity of install settlements and even defensive sites (Coles & Coles 1989; 1996; Nicholas 1988; Nicholas 2003: 262). The variety of activities carried out within and between the wetland and resulting material consequences of such activities, reflect the variability of wetland ecosystem itself. In fact, edges of lakes, rivers, marshes, fens, coastal and estuarine saltmarshes, peatbogs and mires come to be chosen as settling areas and they are even penetrated and explored more systematically.

The wide spatial dimension of these archaeological discoveries, from quite all over the world, and their spread across a very large time-span (since the beginning of the Holocene to nowadays), confirm the importance of wetland exploitation.

These environments vary widely in their location, topography, climate, water regimes and geomorphological features, vegetation and wildlife from place to place, from tundra regions to the tropics and over every continent of the Earth. However, notable wetlands are especially attested in Europe, Americas, Africa, Middle East, Asia and Oceania (Petréquin 1984: 45–49).

After a summarised overview of the common features and stages of formation (and deformation) that characterise the most widespread wetland ecosystems, this chapter will focus on the lakeside settlement: its formation and deformation processes are deepen explored to better contextualise and improve the understanding of the Slovenian case studies, analysed within the next chapter.

The more sites were discovered, the more it became evident that the location of these settlements is mainly related to environmental morphology, without necessarily following a specific construction style (cf. Menotti & O'Sullivan 2013: 12, fig. 3.7.1). The supposed uniqueness of lacustrine villages as a construction built only on stilts in a permanently wet environment, particularly referred to the Alpine-Circum region (Keller's theory), had given way to other possible choices: houses built on the ground, houses with slightly raised floors or houses on piles (true lake-dwellings), according to the subsequent scholarly theories (theories of Reinerth, Paret and Vogt).

A new type of lake-dwellings in peat deposits and marshes was identified and the further discovery of key archaeological sites such as Egolzwil 3 (Vogt 1951), Zug-Sumpf (Speck 1955) and Fiavé (Perini 1975) definitely closed the *Pfahlbauproblem* discussion (Menotti 2001b: 20). This last site shows all types of lake-dwellings, from the classic Keller's pile-settlements to the land-built villages described by Paret. The lay-out of Fiavé lacustrine dwellings consists of three zones and it follows a chronological occupation pattern which goes from the Neolithic to the beginning of the Late Bronze Age. This example pinpointed that the building structure depended upon the morphology of environment and how the lake-dwelling was built over a long time-span.

1. 1 LAKE-DWELLINGS: "TRIUMPH AND TRAGEDY" OF THE POMPEII HYPOTHESIS

The variability which characterises different wetland environments is even reflected by the wide richness and variety of archaeological observables recovered there; this environment ensures a very good preservation of inorganic as much as organic (specially flora and fauna) remains, as its main strengths (Petréquin 1984: 24–26). These findings enable archaeologists to reconstruct palaeonvironmental as well as socio-economic aspects of ancient communities, but they even trigger an invaluable multidisciplinary collaboration between a myriad of different disciplines. From the three most inseparable ones (archaeobotany, archeozoology and geoarchaeology) a number of scientific analyses, from sedimentology to palynology and in some cases even microbiology, come to aid of the lake-dwelling research. Furthermore, the large amount of well-preserved timber found in waterlogged contexts has also contributed to the development of one of the most precise dating techniques in archaeology, i.e. dendrochronology (among others Billamboz & Menotti 2004; Čufar 2007; Haneca et al. 2009; Billamboz 2013; Čufar et al. 2013; Billamboz & Martinelli 2015). This dating method can be used symbiotically with the radiocarbon dates, showing its suitability in calibrating this last dates (Reimer et al. 2004; Menotti 2012: 19). The results obtained from the individual discipline, in the framework of multidisciplinary research, can serve as proof or disproof of the other disciplines' outcomes. This synergetic effort ensures higher precision and accuracy of achieved results (Menotti 2004: 19).

Thus, the potential offered by archaeological research in wetland ecosystem includes:

1) the reconstruction of landscape models, through the analysis of environmental available data;
2) economic evidence of both plants and fauna that may provide precise details of land use, food procurement, preparation and consumption;
3) stratified living and working surfaces on settlement sites and other structures;
4) wooden structural elements recognisable as parts of individually identifiable buildings;
5) they enable dating precision to the year and to the season, creating the possibility of observing the realities of relationship both internal and external;
6) complete artefacts, with handles, bindings and ornamentation rather than only inorganic parts;
7) wholly organic objects as wood, fabric and skin probably otherwise unknown in the archaeological record; and finally
8) patterns of cultural and socio-economic aspects of those prehistoric wetland communities.

According to these "triumphant" conditions (Coles' perspective, Coles & Coles 1989, 1996), are the wetland archaeological contexts reflecting a "Pompeii premise" (see introduction), i.e. are they a fixed picture of the past as it was at the moment of its last deposition?

This condition is not be considered as an absolute assumption because of the potential interference of several biases factors. Shell middens, coastal and river estuarine wetland environments provided an useful example of this circumstance. They are concentrated deposits of shells accumulated as food remains and subject to complex formation/deformation processes. In this context, what could seem to be an original accumulation of shells and other marine resources may be produced by natural agents (Bailey 1975: 52; Bailey et al 1994; Stiner 1994: 177, 182; Bailey & Flamming 2008: 7). As in this case, the luckily occurrence of a "Pompeii premise" in our archaeological record has to be case-by-case tested, avoiding counterproductive conclusions. The possibility that archaeological evidence will eventually come to light as it was originally formed depends essentially on deformation – post-depositional processes. Together with preservation processes, they start soon after the object or the site is abandoned (Schiffer 1987). It is known that organic materials are usually better preserved in waterlogged environments because they are effectively sealed in anaerobic conditions, which prevent artefacts from decaying. However, it is important to point out that various wetland environments, from peat bogs to marshes, would be "deformed" by post-depositional processes in a broad variety of ways that is not limited to the erosive processes but embraces a wide range of disturbances, i.e. the "tragedies". This chapter is focused on an overview of the formation and deformation processes that produced and changed the archaeological record in wetland -and in particular lacustrine- contexts. Several archaeological, ethnographical and experimental case studies, from all over the world and across the prehistory, are described to provide a practical perspective.

2. THE PRE-DEPOSITIONAL STATUS: GENERAL DEFINITION

Sediments are defined as "*those materials deposited at the earth's surface under low temperatures and pressures*" (Pettijohn 1975; Goldberg & MacPhail 2006:11): they create three dimensional sedimentary bodies (deposits) which are subsequently modified in characteristic ways.

Since sediments are so ubiquitous in archaeological sites, it is necessary to have at least a working knowledge of some of these characteristics in order to share this descriptive information; the parameters that we observe in sediments commonly reflect – either individually or collectively – the history of the deposit, including its origin, transport and the nature of the locale where it was deposited, that is, its environment of deposition (Goldberg & MacPhail 2006:11). The sediments can be classified into three basic types (clastic, chemical and organic) of which the first is the most abundant. They are composed of rock fragments or soil material that reflect a history of erosion, transport and deposition by agents such as wind (e.g. sand dunes), running water (e.g. streams, beaches) and gravity (e.g. landslides, slumps, colluvium).

Typical examples of clastic sediments are sand, silt, clay and their lithified results (sandstones, siltstones and shale respectively); furthermore, volcaniclastic debris (such as volcanic ash, blocks, bombs and pyroclastic flow debris) are also considered as clastic sediments (Fisher & Schmincke 1984). The chemical sediments are "*those produced by direct precipitation from solution*" (Goldberg & MacPhail 2006:13); typical examples are the precipitated minerals, as halite (table salt), gypsum (calcium sulphate), calcite or aragonite (both forms of calcium carbonate) derived from strong evaporation of lakes in semi-arid areas or from sheets of calcium carbonate (e.g. travertine or flowstone) in cave environments.

Instead, the biological sediments (third group) are composed mostly of organic materials, especially plant matter; peats or organic rich clays in swampy areas and depressions are characteristic examples. For archaeologists, sediments are the enclosing medium and the environment for the physical and chemical remains that comprise archaeological sites (Wittlesey et al 1982: 28; French 2003: 36; Dowman 1970:5; Rathje & Schiffer 1982: 130; Bullard 1970; Krumbein & Sloss 1963; Blat et al 1972; Shackley 1975: 6; Stein 1985; Stein 1987: 339; Goldberg & Macphail 2006). Finally, the attributes of sediments such as texture and colour, provide evidence on the nature of the environment at the time of sediment deposition and soil formation. Early studies of archaeological sediments, relying upon these characteristics, were directed toward paleoenvironmental reconstruction (Stein 1985). The specific constituents of a sediment, such as mineral types, also provide information about its origin(s) (Schiffer 1987: 224).

On the contrary, soils are deposits of organic/inorganic material (animal, mineral and organic constituents) differentiated into horizons of variable depth which differ from the material below in morphology, physical make-up, chemical properties and composition, and biological characteristics altered *in situ* through time (Joffe 1949; Schiffer 1987:201; Holliday 2004; French 2003: 35; Shackley 1981: 257; Bullard 1970; Banning 2000: 243). Some scholars (Jenny 1941; Bunting 1967; Fitzpatrick 1986; French 2003: 36–37; Goldberg & Macphail 2006: 43; Holliday 2004: 261 and following) enumerated five factors that affect the formation of soils:
1) climate;
2) organism;
3) relief or topography;
4) parent material;
5) time.

The climate (1) locally and seasonally affects temperature and rainfall, which in turn influences soil development and type (Bunting 1967). Temperature determines humidity, evaporation, microclimates, length and intensity of the growing season and the type of vegetation able to grow. Rainfall affects most other factors, such as the amount and type of vegetation and the amount of leaching and removal of nutrients or bases from the soil (French 2003: 37).

Instead, the living organisms (2) affect the physical structure of the soil (Bunting 1967). They are responsible for mixing, commination, aeration and the formation of humus-clay complexes which tend to give soil stability. Different types of organism are found in different soil conditions, for example earthworms in basic conditions and fungi in acidic conditions (French 2003: 36).

Furthermore, the physical and chemical weathering processes which create the soil, also affect the relief pattern (3) and drainage characteristics of the landscape. Mechanical effects and transformations such as transport, redeposition of soil by erosion agencies (frost shattering, wind and water abrasion) and the disruptive effects of plants and animals (rooting and burrowing) are caused by physical processes (Bunting 1967; Limbrey 1975; French 2003: 39). The relief also affect many soil properties such as the depth or loss of soils on slopes and in valleys (droughty ridges and uplands, eroding slopes, colluvial footslopes, and boggy valleys) as well as the moisture gradient, amount and variety of vegetation, altitude and aspect, soil water run-off and filtration (Bunting 1967). The spatial variability within a given soil type is caused by the parent material (4) (type of rock or substrate) which provides its basic constituent. Finally the time (5) represents the tool through which all these changes took place; indeed, the soils can be considered as a complete ecosystem: it is a dynamic and open system comprising the living and non-living parts of the soil environment acting as a unit (Odum 1963; Sheals 1969; Birkeland 1974; Mandel & Bettis 2001; French 2003: 38).

Although the archaeologists use the terms soils and sediment synonymously, it is important to distinguish between them (Butzer 1971; Goldberg & Macphail 2006; Balme & Paterson 2006: 50). The concepts are quite different, and misunderstandings arise in archaeology overuse and misuse of the terms and, especially, the underpinning concepts. Soils are made up of particles of broken rocks and organic materials. Their formation (pedogenesis) results from biological, physical and chemical processes on the parent rock: the elements may become hydrated or leached, and biological activity, whether involving bacteria or larger plants and soil animals, mixes organic matter with mineral material. The sum total is the initiation of soil horizon formation, called horizonation (soil materials were differentiated into profiles which have horizons). Indeed, the soils in archaeological contexts are evidence of past variability situations which form and mature gradually; they took place in a single essentially stable, extant and exposed substrate. Therefore soil forming episode is often termed a period "stability" ("stasis"). The soil's cyclic history of development can also be interrupted many times (Shackley 1981: 18–19; Goldberg & MacPhail 2006: 27; Balme & Paterson 2006: 50).

On the contrary, sediments are made up of particles that are the result of the breaking down of natural occurring minerals by weathering. Indeed, a sediment has a dynamic history which encompasses erosion, transport and deposition over a landscape or area (e.g. among others glacial till, Aeolian loess, beach sand). Therefore, an archaeological deposit is clearly a sediment and not a soil, with a source (e.g. a combustion feature) and a mode of deposition (e.g. dumping, accumulation of stabling waste). Like any sediment, an archaeological deposit itself may have accumulated through sedimentary processes (geogenic and/or pedogenic in character) and may have been affected by post-depositional processes which destroyed original layering and transformed or completely removed some easily weatherable materials, such as wood ash (Weiner et al. 1995; Goldberg & Mac Phail 2006: 27).

In sum, sediments and soils constitute the natural context which held and retained archaeological observables; the reasonable identification and analysis of the processes which govern their formation can inform about the history of both materials and site itself, the agents and environment in which human behaviours that defined the site were carried out (Shackley 1981: 262). Furthermore, this evidence is essential in helping to reconstruct both past environmental events and changes (Goudie 1993; French 2003: 35). In terms of process, artefacts can be considered as sedimentary particles accumulated both mechanically or chemically: from a geo-archaeological perspective they are a special kind of geologic and bio-stratigraphic deposit which contribute to the final character of the archaeological record. They consist of sediments that contain the remains or traces of past life, "*either due to the presence of objects modified by people or the remnants of materials – rocks, plants or animals- used by humans in the past*" (Rapp & Hill 2006: 25). Because the same principles apply to sedimentary settings containing artefacts or other archaeological features, archaeologists need to understand sedimentologic concept. These latter form the basis for better evaluations of the environmental contexts of sites and the conditions that affect the final archaeological record. Sediments and soils provide even a systematic framework useful to describe the deposits associated with artefacts where the results of human behaviours held in the c-transforms (Rapp & Hill 2006: 25).

2.1 THE FIRST-NATURAL FORMATION PROCESS

Exploring formation processes that generated the archaeological record, the content (archaeological observables) as well as the container (environmental setting) have to be analysed. Traces of past activities are hence accumulated in specific landscape and material consequences embraced into the archaeological layer sediment; it can be defined as the result of natural pre-depositional formation process, that took place before the people chose to interact with the surrounding environment and exploit it.

The identification and interpretation of distinctive bodies showed by sediment revealed different processes which during the past may operate, not necessarily at the same rate or over the same time intervals and spatial locations. The bulk of inclusions may derive from animals and plants living in or on sediments subsequent to deposition (remnant); others may be elements of communities that were carried along with the sediments, finally coming to rest far from their native habitats (re-deposited). The remnant (autochthonous) fossils belong normally to times following the subaerial depositional event itself. Their environmental signals must be evaluated for their chronological relationships to the depositional event and to the archaeological event under investigation.

Naturally re-deposited (allochthonous) materials belong to earlier times and distant space in relation to any deposit that contains them. As elements of sedimentary history, they represent environmental conditions as source; they may consequently either complement or contradict the autochthonous evidence. How much time and space separates them from the deposit itself is to be determined in each case (Dincauze 2001: 272). Wetland ecosystems, such as mires, bog, fens, marshes and swamps represent our depositional environments and are intermediate between subaerial and subaqueous environments.

Although listing all possible wetland ecosystems is not among the aims of this book, main features of most common wet environments where archaeological record is usually formed are highlighted with a brief overview. The lacustrine wetland contexts will be analysed more in detail.

2.2. THE WETLAND ECOSYSTEMS: FEATURES AND FORMATION

Wetlands, as the link between land and water, are some of the most productive ecosystems in the world. They are often found at the interface of terrestrial ecosystems (such as upland forests and grasslands) and aquatic systems (such as lakes, rivers, and estuaries) (Butzer 1971; Shackley 1981; Mitsch & Gosselink 1993; 2000; 2007; Dincauze 2000; French 2003; Goldberg & MacPhail 2006) (*Fig. 1.1*). Some are isolated from deep-water habitats and are maintained entirely by groundwater and precipitation. Even though they show structural and functional overlap and physical interface with terrestrial and aquatic systems, wetlands are different from these other ecosystems in so many respects that they must be considered as a distinctive class (*Fig. 1.2*).

Wetland sites are characterised by several common features: all have shallow water or saturated soil where accumulated organic plant material are decomposed slowly. Hence, this ecosystem supports biota such as a variety of plants and animals adapted to the saturated wet conditions (hydrophytes), while an absence of flooding-intolerant biota is attested. Wetlands are characterised by the presence of water, either at the surface or within the root zone and often have unique soil con-

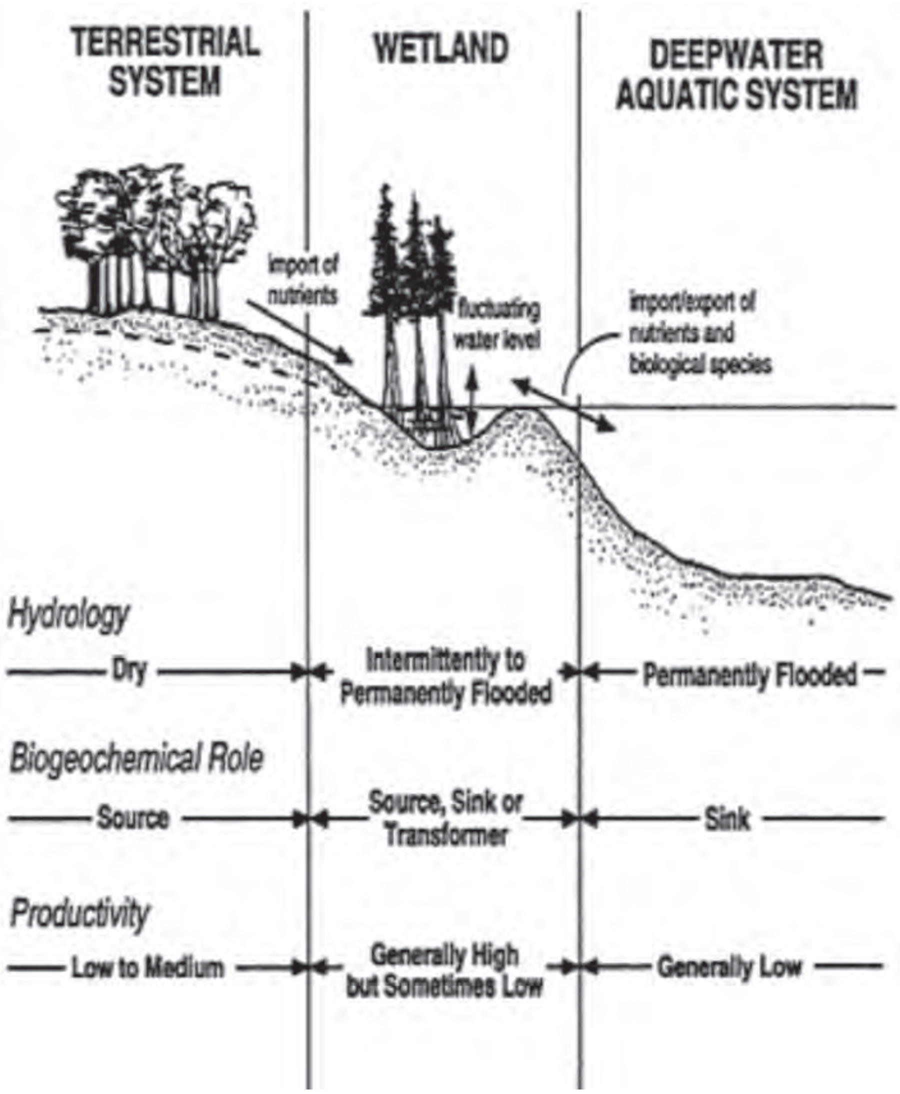


Fig. 1.1: Wetland can be part of a continuum between terrestrial and deepwater aquatic systems (from Mitsch, Gosselink, 1993, Fig. 2.1A).

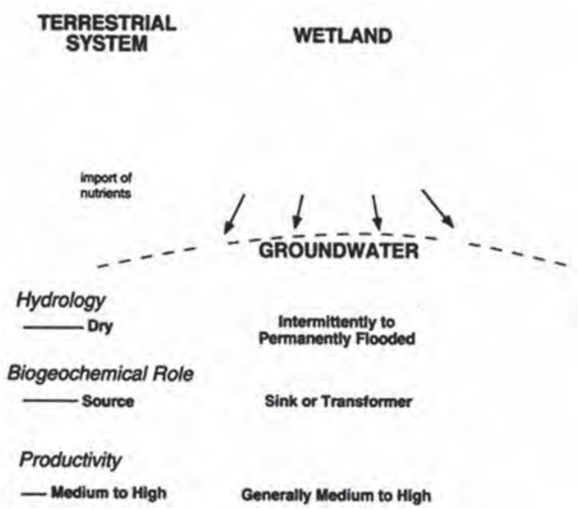


Fig. 1.2: Isolated from connections with water bodies (from Mitsch, Gosselink 1993, Fig. 2.1B).

ditions that, as mentioned above, differ from adjacent uplands. Although climate and geomorphology define the degree to which wetlands can exist, the starting point is the hydrology. This feature, in turn, affects and defines physical and chemical wetland properties (such as nutrient availability, pH and environment, including soils), which determines what and how much biota, including vegetation, is found in the wetland (*Fig. 1.3*) (Mitsch & Gosselink 1993; 2000; 2007; Retallack 1990). The general definition of wetland includes multiple ecosystems; although some types of formation processes are the same in all cases, more specific peculiarities can still be individually detected. In the pursuit of our goal, the processes which took place in the formation of wetland contexts settled during prehistory are highlighted. The term "peat" is generically used for any wetland that has at some point accumulated partially decayed plant matter because of incomplete decomposition. The result can be an in-filled lake (terrestrialisation) or a process of waterlogging less wet mineral soils (paludification) (Dierßen 2003; Menotti 2012: 11) (*Fig. 1.4*).

Peat formation is even favoured by factors that reduce metabolic activity of micro-organisms, such as water saturation in the uppermost peat layers (the unsatured zone defined as acrotelm) especially in eutrophic areas. Peatlands are adapted to the extreme conditions of high water and low oxygen content of toxic elements and low availability of plant nutrients. Their water chemistry varies from alkaline to acidic. Peats occur in all continents, from the tropical to the boreal and Arctic zones, from the sea level to high alpine conditions (Joosten & Clarke 2002). Many terms have been used to describe peat-forming wetlands, particularly in Europe (Verhoeven 1992; Glooschenko et al. 1993). For instance, the term "mire" refers to any peat-accumulating wetland, either bogs and fens. The slow decomposition of mosses, especially species of *Sphagnum* growing in acidic groundwater pools or shallow ponds, creates the classic bogs (Maltby & Barker 2009: 45). Fens are boggy landscapes formed in alkaline or neutral groundwater; they receive some drainage from surrounding areas and usually support marsh-like vegetation (herbaceous and woody plant species). Carrs are variants supporting woody swamp vegetation in addition to peat. A type of bog that differs from the raised is the blanket bog. In them, the drainage of water (especially on hills and mountains) is impeded by leaching and iron pan formation, which results in the formation and coverage of peat

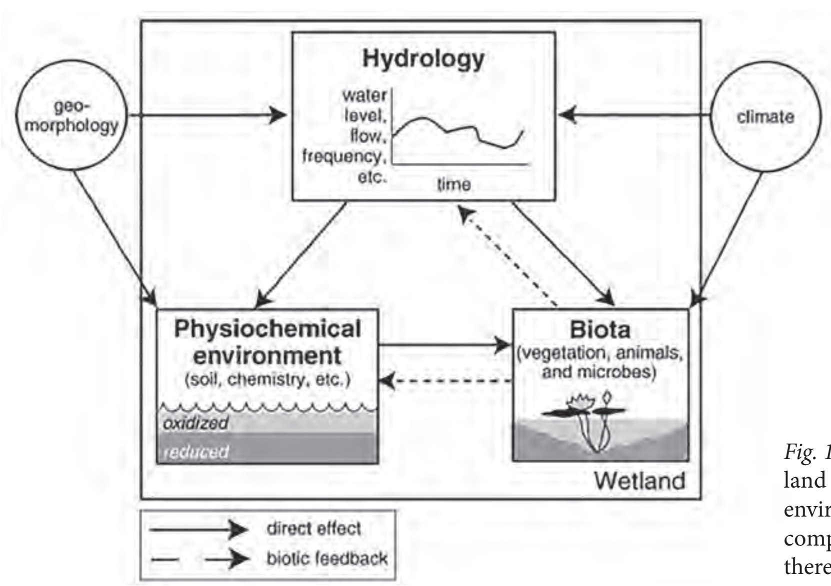


Fig. 1.3: The three-component basis of a wetland definition: hydrology, physiochemical environment and biota. Note that these three components are not independent and that there is a significant feedback from the biota.

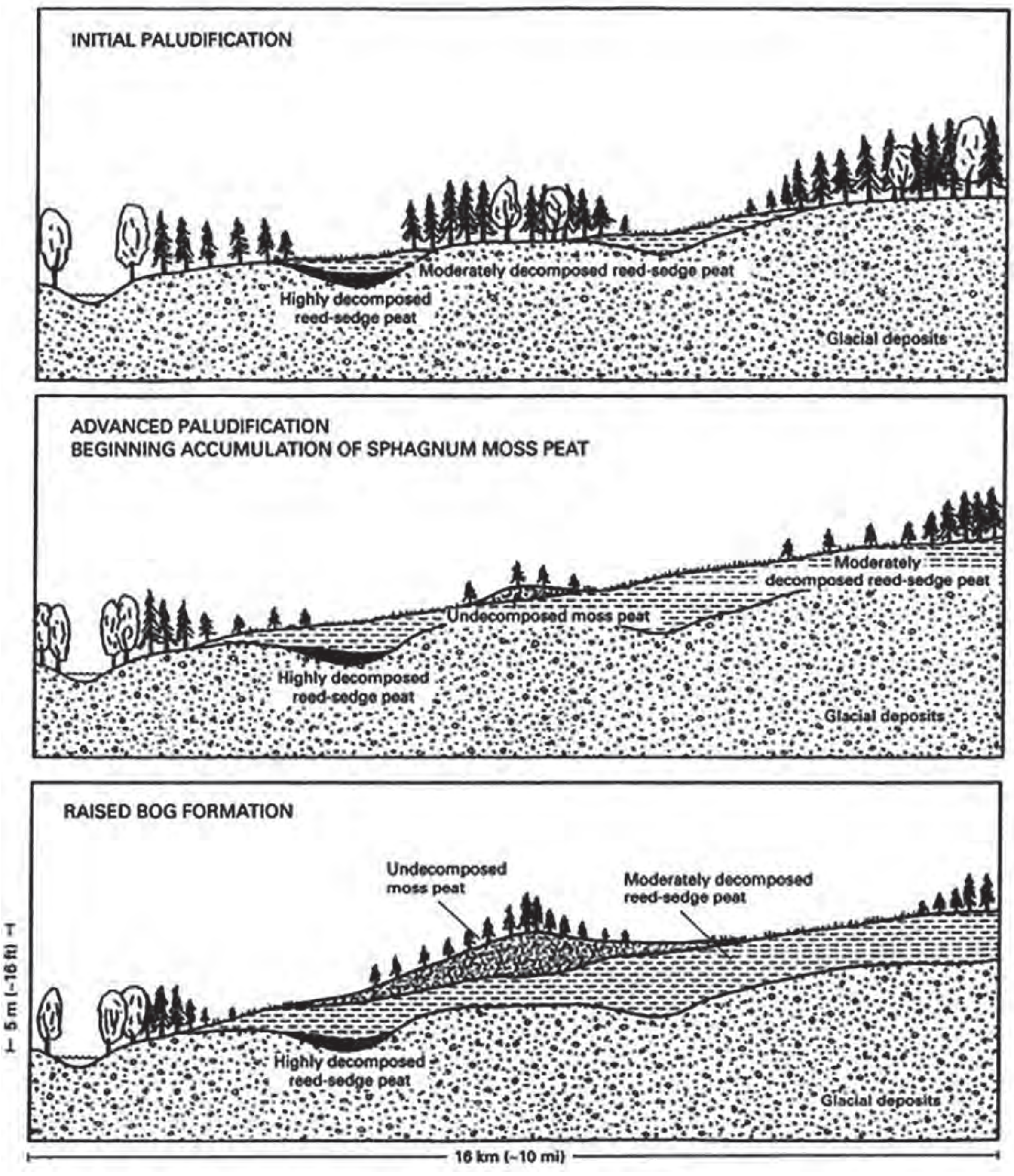


Fig. 1.4: Stages in paludification of a northern landscape (from Minnesota DNR 1987, Fig. 3).

(usually moss and heather) over an originally "dry" surface (Hammond 1981; Maltby 2009; Menotti 2012: 11).

Other wetland contexts are bottomlands that consist of lowlands along rivers; in most cases they are located on alluvial and periodically flooded floodplains. The process of wetland development in river floodplains can be summarised as follows: marine transgression (during periods of sea-level rise) results in an impeded run-off of the river's tributaries as the hydraulic gradient is reduced. This impeded run-off results in more frequent and increased longevity of overbank floodings and rising groundwater tables. This, in turn, favours the growth of species that tolerate a high groundwater table, especially Alnus (alder) in areas which previously were typically meadows (within the river floodplains) or deciduous forests (on higher ground). The high groundwater table and frequent floods inhibit the humidification of plant material, resulting in the development of floodplain peats or mires. Where the floodplains are unconstrained, a landward expansion of the (floodplain) mires is observed, during marine transgression. On the side of the river or estuary, reed swamps, saltmarsh and mudbanks may develop, resulting in peat and clastic sediments, overlying the basal peats. In periods of marine regression, a seaward expansion of the floodplain mire can be observed, resulting in an intercalated or upper peat. Furthermore, fresh or saltwater wetlands characterised by emergent herbaceous vegetation adapted to waterlogged soils are marshes. They occur in areas that are frequently or continuously inundated with water and they are most often associated with mineral soils that do not accumulate peat (Maltby & Barker 2009: 44–45). When marshes are dominated by wood vegetation (in particular trees and shrubs in North America and Phragmites in Europe), they are defined as swamps. These are terrestrial habitats formed where woody vegetation alternates with stretches of open water (Sharitz & Mitsch 1993; Dincauze 2001: 314; Maltby & Barker 2009: 44–45). Furthermore, along low-lying coastlines, deposit of salt marsh and other swamplands are attested; they are very similar to those of mudflat and lagoonal deposits. The latter includes coarse (fine sand) as well as fine (silt and clay) laminae, with some laminae rich in detrital organic matter (Goldberg & MacPhail 2006: 161).

During their formation, the deposits of salt marsh and other swamplands have been affected by subaerial weathering, biological activity, surface and channel water flow. There are also the lacustrine environments, often located in interfacing areas between wet and dry conditions. Lakes are closed bodies of standing water that vary considerably in size. The basins where they are formed have numerous origins, including volcanic and meteorite craters, glacial depressions left by decaying ice (kettles) or retreating ice (moraines), alluvial floodplains (oxbows and avulsed channels) or karstic depressions (sinkholes) (Goldberg & Macphail 2006: 112). Generally, lakes are categorised as either open or closed; the former, exorheic, have an outlet and consequently remain fresh, without concentrations of salts. They tend to be stable and have shorelines with short-range fluctuations in lake level. The latter (endorheic) on the other hand have not outflow and dissolved solutes are concentrated; they are unstable and subjected to large inter-and intra-annual fluctuations in volume and position of the shoreline. The formation of lacustrine sediments is characterised by several phases. Clay and silty sediments are transported into the lake from streams: much of the coarser load is dropped there along the margins, while the finer material is carried in suspension by the combined action of currents-winds and they eventually settle to the bottom. At the same time, wind-induced waves and currents may also redistribute coarser materials around the coastal margins (Nichols 1999; Goldberg & MacPhail 2006: 112). The lacustrine deposits include evaporites (usually gypsum or salts), calcareous beds (including chalk), marls, silts and clays, sands and organic matters (Butzer 1971: 185–7). Evaporites consist mainly of gypsum (calcium sulphate) and other salts such as sodium, magnesium and potassium chlorides or sulphates. Such beds frequently indicate desiccation or lake shrinkage during the dry season or long-term reduction of a larger lake to a lagoon or salt pan, while lacustrine chalks usually indicate fluctuation of oxygen content. Freshwater marl sedimentation is commonly confined to comparatively small water bodies and the lime content included in the lake deposits may be derived by plant or inorganic agencies. This brief explanation of the most exploited wetland ecosystems is suitable to clarify the main features of depositional contexts and landscape settings in which traces of past activities have been attested, from the dawn of civilisation. A selection of some case studies, e.g. archaeological settlements retrieved in lakeshore, will be introduced, to reconstruct all the tiles of our archaeological record – "puzzle", starting from the first pre-depositional status.

2.3. THE PRE-DEPOSITIONAL STATUS OF WETLAND LACUSTRINE ARCHAEOLOGICAL CONTEXTS

Among the multiplicity of wetland ecosystems, our research is focused on pile-dwellings – lakeside settlement contexts. In the *Fig. 1.5*, a model of the most widespread geological layers of some morenic south-alpine italian lakeside environments is summarised (Leonardi & Balista 1996: 201).

The majority of these archaeological contexts seemed to be settled during the past, imposing on a similar natural pre-depositional layer defined as lake marl stratum or silty-clay gyttja.

This layer, composed by carbonates (silty carbonate mud, micrite), is formed by limnic precipitation in many lakes of the temperate zone, where the water depth ranges between 0.5 and 12 m (Muckle 1942; Schindler 1976; Brochier 1983; Ismail-Meyer et al. 2013: 321).

In particular, in some archaeological sites in the Circum-Alpine region, the laminated micrite is deposited on the lake bottom as carbonate mud, formed by seasonal natural processes (Platt & Wright 1991; Freyter & Verrecchia 2002).

Depending on the geomorphological situation of the riparian zone and the hinterland, changing amounts of fluvial sands can be added to the lake marl (Ismail-Meyer et al 2013: 321). The sediment often shows alternating sequences of denser micrite and looser sandy laminations, containing more algal remains and molluscs; amounts of fluvial sands can be added to the lake marl depending on the geomorphological situation of the hinterland (*Fig. 1.6*).

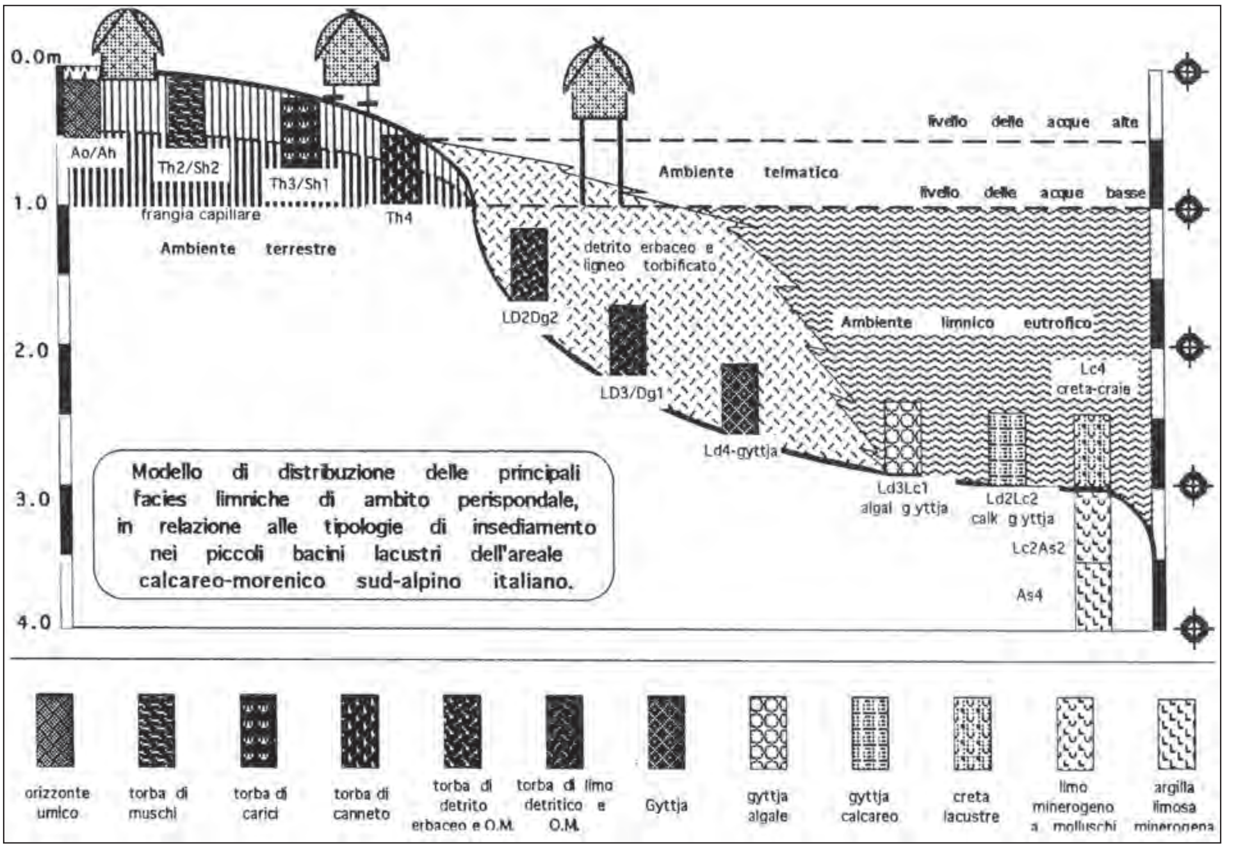


Fig. 1.5: Lakeside settlements, stratigraphic model with related sedimentary facies (from Balista, Leonardi 1996, 201, Fig. 3).

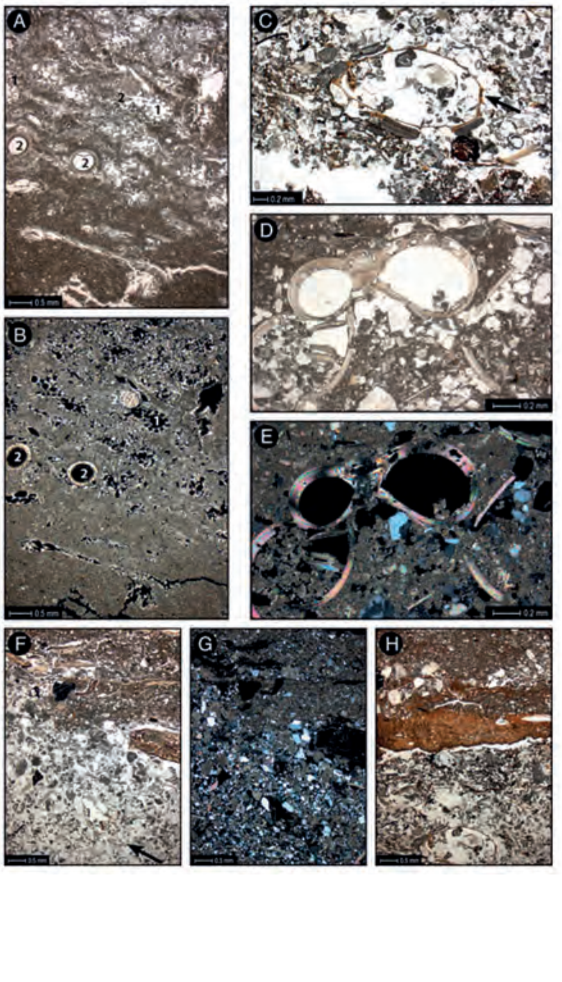


Fig. 1.6: Micromorphological analyses on the lake marl: A) Stratified, carbonate rich lake marl with cross-section through stems of chara-algae (1) and oogonia (2) (Zug-Riedmatt M96); B) same as A), the chara stems (1) and carbonate rim of the oogonia (2) are easily recognizable; C) cross-section through a caddis fly larva (arrow), with adherent sand grains (Arbon-Bleiche 3 M1036); D) weathered mollusc shells in a sandy lake marl (Risch-Aabach M4); E) same as (D) (from Ismail-Meyer, Rentzel, Wiemann 2013, 327, Fig. 7).

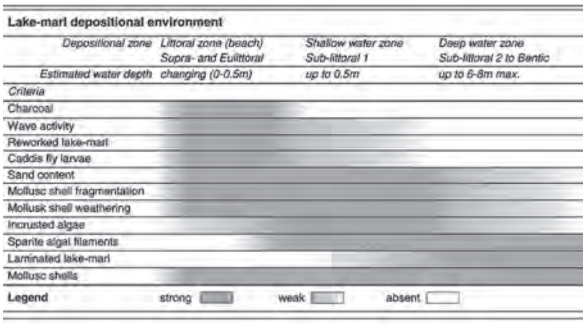


Fig. 1.7: Division of depositional environments and their recognition from the characteristics of lake marl (from Ismail-Meyer, Rentzel, Wiemann 2013, 326, App. III).

Thanks to detailed results of micromorphological analyses applied to some Neolithic lakeshore settlements (such as Arbon-Bleiche 3; Cham-Eslen; Zug-Riedmatt; Risch-Aabach; Stansstad-Kehrsiten; Lobsigesee; from Ismail-Meyer et al. 2013), specific depositional environment can be recognised in the littoral zone.

The currents and wave action cause reworking, reprocessing and sorting of lake marl: in particular, formation below the wave base in calm sub-littoral conditions produced finely laminated lake marl (sub-littoral 2 to bentic), whereas reworking by waves in shallow waters produced homogeneous layers of lake marl, with fragmented mollusc shells and algal filaments (sub-littoral 1) (*Fig. 1.7*) (Brochier 1983, 1989; Pétrequin & Magny 1986; Ostendorp 1990a; Ismail-Meyer & Rentzel 2004; Digerfeldt et al. 2007; Ismail-Meyer et al. 2013: 321).

After the removal of finer particles, sand became enriched and a lag deposit was formed. At Constance lake (e.g. Arbon-Bleiche 3, Hornstaad and Allensbach), a leaching of the fine matrix during the Neolithic period took place and consequently sandy beach deposits were formed (Ostendorp 1990a, 1990b; Ismail-Meyer & Rentzel 2004; Ismail-Meyer et al. 2013: 321).

In addition, wave erosion prevents a further accumulation in the littoral zone, leading to the progradation of the shoreline and the formation of a flat surface that can expand toward the lake centre with time (Magny 1978; Pétrequin & Magny 1986; Platt & Wright 1991; Magny 1992a).

The same pre-depositional natural sediment is attested at some European lake-side settlements: among those, some are included into the Circum-Alpine region (such as the Alpenquai lake-dwelling on Zurich Lake (Wiemann et al. 2012: 66), in central Italy (such as at the Mezzano Lake, Lazio, Central Italy (homogeneous and laminated gyttia with interbedded layers of turbidites)

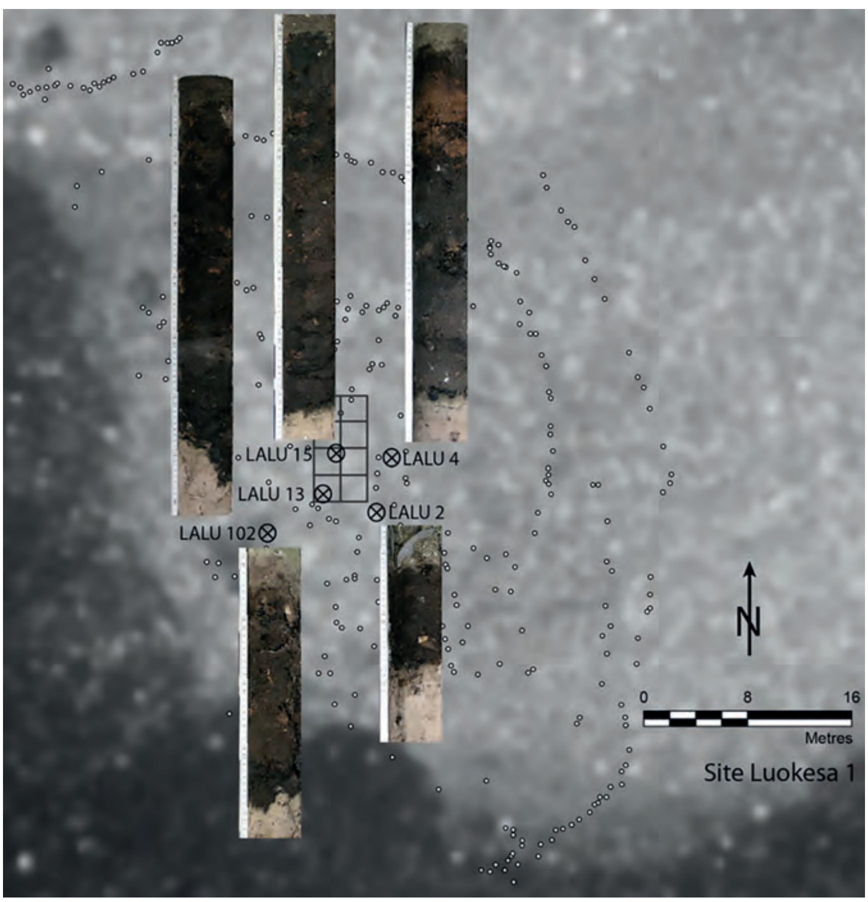


Fig. 1.8: Lake marl platform (light grey) with the site L1, the piles (dots), the measurement grid for the excavation and the micromorphologically analysed profile columns (crosses) with photographs of the opened columns included (Pranckėnaitė, Pollmann; from Ismail-Meyer 2014, 370, Fig. 3).

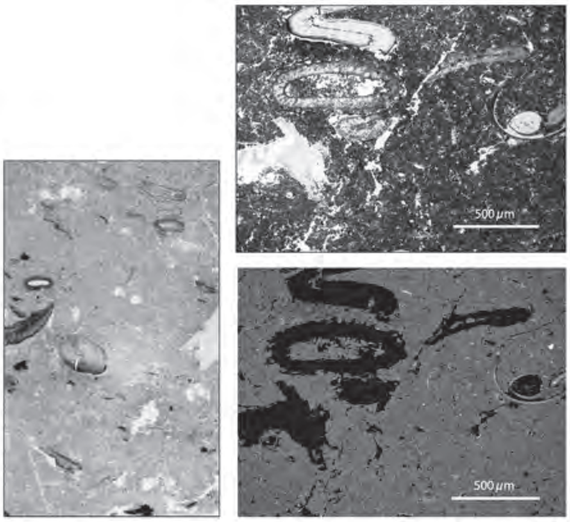


Fig. 1.9: Thin section images from Luokesas Lake L2, S3. Typical fabric of the lake marl (grey micritic fabric and plant remains) (from Lewis 2007, 41, Fig. 5).

(Sadori et al. 2004: 5) and some North-European archaeological contexts (such as the sites 1 and 2 recovered at the Luokesas Lake (Moletai District of Eastern Lithuania) (*Figs. 1.8* and *1.9*) (Menotti et al. 2005: 385,397; Lewis 2007: 33,3 6, 47–8; Prenckénaité 2014).

Among the French archaeological settlements, at the sites of Chindrieux and Tresserve, located on the eastern shore of Bourget Lake (Savoie, France), the basal layer is represented by a lake marl unit (Gauthier & Richard 2009: 112, 114). In Slovenia, three archaeological pile-dwellings recovered at the Ljubjansko barje (Ger. Das Laibacher Moor, situated in central Slovenia, near the capital Ljubljana) show a sedimentary sequence that starts with a layer of lake marl (Melik 1946; Tancik 1965; Verbič & Horvat 2009). In particular, at the site Resnikov prekop, this lake marl or gyttja is predominated by a carbonate-rich sediments, composed especially by homogeneous grey clay, snail and bivalve shells (Turk & Velušček 2013: 186). The same depositional layer characterises the Blatna Brezovica and Stare gmajne, that show a lower concentration of carbonate sediment (Turk & Velušček 2013: 187). In Italy, across the shore of the Lucone Lake – a former lake in the western amphitheatre system of the Garda Lake – pile-dwelling settlements from the Early-Middle Bronze Age are attested. According to the data derived from one core (LUC-1 of 7 m length, recovered at a distance of only 100 m from one settlement), the basal sediment consisted of silty clay characterised by high percentages of non-carbonate minerals and increasing organic matter.

This layer is followed by a dark silty gyttja alternated with a clay gyttja (Valsecchi et al. 2006: 99–113). Moreover, a similar natural basal layer characterised the site of Ledro I, located in the Ledro Lake, on the southern slope of the Alps, at c. 6 km north of Garda Lake. In particular, Ledro I is located on the southeastern shore, just west of an area occupied by Middle Bronze Age lake-dwellings in the outlet area (Magny et al. 2009: 577). The basal deposit is formed by a pebble beach layer, typical of the lake-shore sedimentation; a carbonate lake-marl layer finally overlaid the morainic deposits (Magny et al. 2009: 580) (*Fig. 1.10*). At the pile-dwelling site of Bande di Cavriana the sedimentary record has been recon-

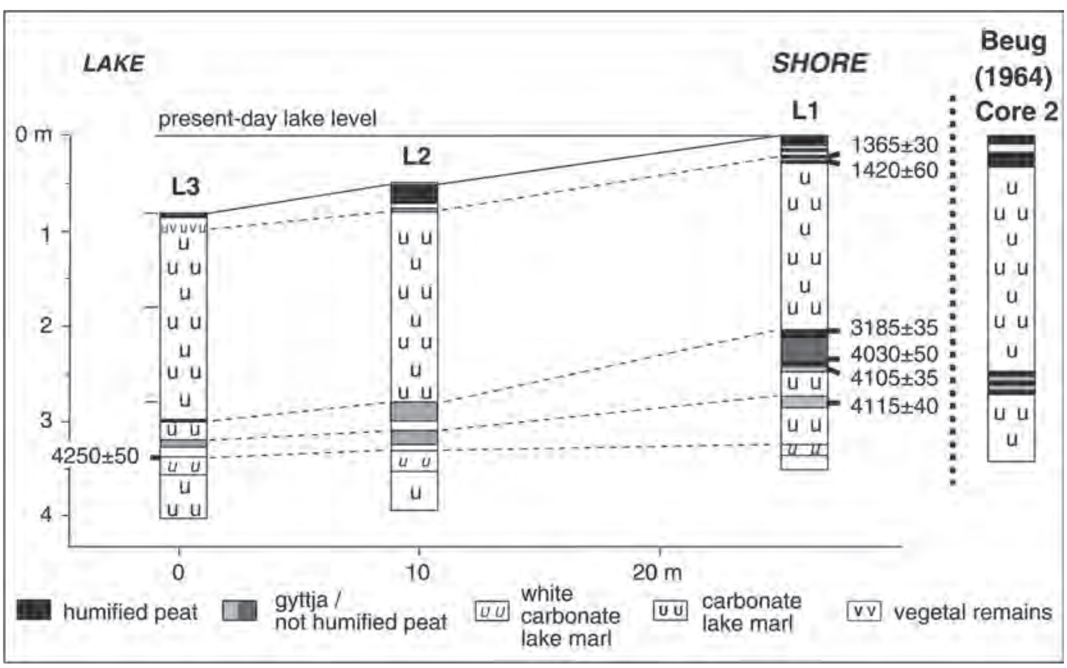


Fig. 1.10: Core transect established on Ledro I. On the right the lithostratigraphic profile of core 2 pollen analysed by Beug (1964) is shown (from Magny et al. 2009, 576, Fig. 1).

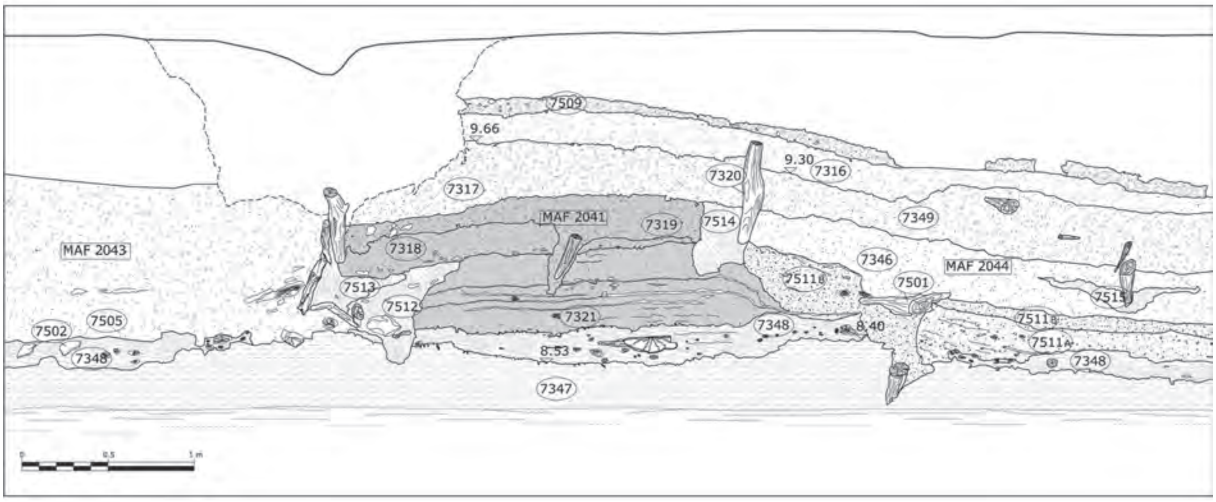


Fig. 1.11: Site's trench, stratigraphic section with highlighted the different layers (from Albore Livadie et al. 2008, 16, Fig. 5).

structed thanks to a series of coring collected along a N-S transect (Zanon et al. 2019: 2–4); the basal stratigraphic units, which preceded the establishment of the pile dwelling, are characterised by compact and carbonate mud with rare fauna remains (*Unio* sp. shells) (SU 1 and 2), with the presence of dark-brown detritus gyttja, and carbonate lake marl (SU 3), comparable in composition to SU 2. At the site of La Draga, on the edge of Banyoles Lake (Girona, Spain), the base level of the stratigraphic sequence consists of carbonate sands of bioclastic origin (Level IX) (Palomo et al. 2014: 62). Other lakeside settlements are characterised by different natural basal deposits produced by the combined action of different lake formation processes and environmental settings. At the site of Dispilio, located on the southern shore of Orestias Lake (Kastoria, northern Greece) (Hourmouziades 1996; Menotti 2004), the lacustrine sediments of the pre-occupation show relatively deep-lake sedimentary environments (bluish muds and sands).

Furthermore, discrete horizons of olive gray sediment associated with root casts, organic staining and decayed organic matter are attested, indicating falls in lake level (Karkanas et al. 2011: 84, 107). At the site of Ballyarnet, on the edge of Ballyarnet Lake (4 km to the north-west of Derry city, Ireland) some archaeological remains of a lake-settlement were retrieved. In this case, a peat deposit rich in glacial clay characterised the basal natural sediment (Ó Néill et al. 2007: 42–44). In the pile-dwelling of San Savino (San Savino site 2), located on the shore of Trasimeno Lake (Magione, Perugia, Central Italy) (Angelini et al. 2012), the peat deposit, recovered below the anthropic layer, is a grey-greenish silty sediment with shells (Angelini et al. 2012: 6). Moreover, a number of prehistoric settlements, for instance in Italy, were built along the rivers (e.g. Isolone del Mincio (Piccoli & Peroni 1992; Aspes 1997), San Pietro Canàr (Balista & Bellintani 1998), Lagona at Poggiomarino (Albore Livadie 2005; Albore Livadie et al. 2008; Cicirelli et al. 2008) or lagoons (e.g. Stagno at Livorno (Zanini & Martinelli 2005; Giachi et al. 2010). Focusing on river settlements, at the site of Lagona (Poggiomarino), the recent stratigraphic analysis are located on the right bank of a wide deviation drawn by the current Sarno River. Here, a salty clay base layer (SU 7347) has been identified. This sediment, typical of a fluvial-lacustrine environment, is characterised by an extremely low-energy hydrological regime and rich on aquatic flora and shells. It has been extended horizontally and has been recovered from some of the site's trenches (*Fig. 1.11*).

At the site of San Pietro Canàr, anthropogenic deposits overlapped a base sequence of peat deposits which were covered in alluvial sediments (Balista & Bellintani 1998).

Regarding the lagoons, the site of Stagno constitutes a useful case: this pile-dwelling is located near the city of Livorno, about 7 km from the present coastline, at the southernmost limit of an ancient swamp. The archaeological deposit consisted of clayey layers alternated with organic clay banks; at the bottom, in the sector C (Ia), a homogeneous level with shells indicates the former presence of a brackish lagoon (SU 118 and 114). A lagoonal level sealed the deposit, suggesting that the natural environment preceding the pile-dwelling settlement was re-established after its abandonment (Giachi et al. 2010: 1261). Similarly, many lake-dwelling-like settlements have been discovered in marsh and fen-lands, the *Moorsidlungen* (e.g. Gachnang-Niederwil Egelsee (Hasenfratz & Casparie 2006), and Wasserburg-Buchau (Reinerth 1928; Kimmig 1992).

The outstanding case of *Terramare* settlements of Po Valley deserves finally a particular mention; the "*palafitte*

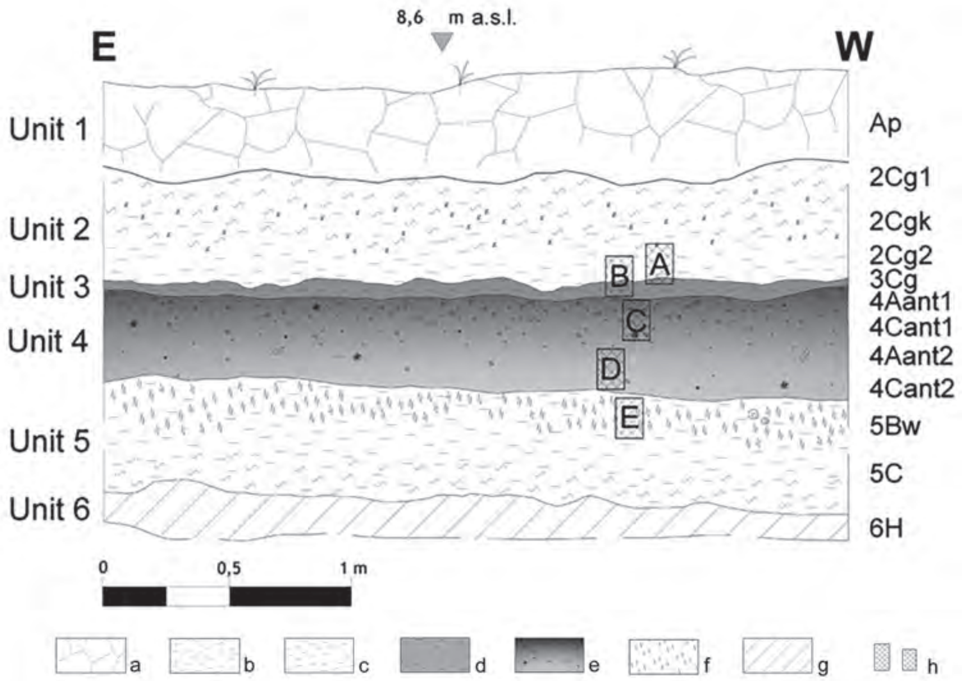


Fig. 1.12: Fondo Paviani. Profile 1, above – indication of main litho-stratigraphic units and below – pedogenic horizons. a) Present-day plough horizon. b) Silty clays. c) Clays. d) Organic clays. e) Bronze Age anthropogenic deposits. f) Olive-brown concretions. g) Peat. h) Thin sections (from Nicosia et al. 2011, 283, Fig. 4).

a secco" are settlements surrounded by a moat and an earthen rampart (among others Bernabò Brea & Mutti 1994; Bernabò Brea et al. 1997; Pearce 1998; Cremaschi et al. 2006; Nicosia et al. 2011: 280–92; Menotti 2012: 155). These sites have been identified both south of Po river (Emilia-Romagna) (Cremaschi 1997; Cremaschi et al. 2006) and north of that river, in lower Venetian plain and southern Lombardy (Balista et al. 1998; Cremaschi et al. 2006; Nicosia et al. 2011: 280). At Fondo Paviani, the base of the archaeological sequence is characterised by peat deposits, covered by alluvial sediment. They culminated with a clay-textured horizon (5Bw), the substratum which embraced archaeological deposit (*Fig. 1.12*) (Nicosia et al. 2011: 283). During this stage – as in the later phases of formation processes – lake levels start to change due to climatic fluctuations which occurred during the Holocene (Magny 1978; Magny et al. 2007, 2009; Menotti 2001b, 2004, 2012). Such fluctuations have been documented in some cases using accurate micromorphological analyses. These showed that the lake level decreased, enabling the emersion of lake marl that formed a hard compact surface (Schurrenberger et al. 2003): above this layer, flat surfaces were formed. At some Neolithic lakeside settlements a rather good preservation of pollen and mollusc shells could hint to a short hiatus (presumably a few weeks) that occurred just before the settlement was founded (Magny 1978; Wallace 1999; Ismail-Meyer 2010; Ismail-Meyer et al. 2013: 325).

3. THE INTRA-DEPOSITIONAL PHASE

A lake- or pile-dwelling is essentially a form of settlement construction adapted to specific humid and damp water environments. Although the conscious choice of inhabit wetland locations was made for various possible reasons, it had advantages as well as disadvantages. Several factors, including the potential ease of construction and life, have been suggested to justify the occupation of the lakeshore (Barfield 1994: 132; Pétrequin 1984: 321; Pétrequin & Bailly 2004; Menotti & Pranckėnaitė 2008; Pydyn and Gackowski 2011: 134; Menotti 2012, 2013).

However, according to Jennings' perspective, concept of "ease" are entirely subjective and the extent to which these factors influenced the choice to occupy wetland environments is uncertain (Jenning 2014: 81). Hence, humid settlements are characterised by specific problems, such as the poor preservation of agricultural products and health difficulties, that are not encountered in the inland (Horden & Purcell 2000: ch. VI. 5); furthermore, unpredictable lake—level fluctuations may affect the lifespan of settlements and houses (Ebersbach 2013: 285).

Defensive aspects could partially motivate the occupation, although this may have been true only in some situations. For instance, while certain sites show indications of a defensive function, such as Wasserburg-Buchau (Reinerth 1928; Kimmig 1992; Billamboz et al. 2009), Siedlung-Forschner (Menotti 2001b: 130; Siedlungsarchäologie im Alpenvorland XI 2009), and Greifensee-Böschen (Eberschweiler et al. 2007), others do not appear particularly defensive in nature (such as Hauterive-Champréveyres (Benkert & Egger 1986; Rychner-Faraggi 1993), Ürschhausen-Horn (Gollnisch-Moos 1999), Zurich-Alpenquai (Viollier et al. 1924; Mäder 2001a-b) and Cortaillod-Est (Arnold 1990) (Jennings 2014: 81).

It is also possible that lake-settlements were occupied to access and control trade routes, particularly where water features constituted natural crossroads; in these contexts, models, peoples and objects seem to have moved during the past.

Interaction between human communities and environment as well as the preference for specific features of the landscape have certainly influenced the choice of where to locate settlements; people could take advantage of availability of agriculturally productive land, the presence of rich wetland resources, such as fish, waterfowl and climatically favourable conditions (Menotti 2012: 104–106). During the Neolithic Age, when the lake levels were low and flat moraine shoals near the shore could easily be utilised as "empty platforms", some lake-dwellings in the Circum-Alpine region started to be settled (Magny 1978; Magny 1993a–b; Monnier et al. 1991; Ismail-Meyer et al. 2013: 324).

A similar phenomenon occurred in Northern Europe (such as in the case of the settlements at Valgjärv Lake (Koorküla, Estonia), where the settlers found a favourable place on a peninsula in the lake, which was later covered by water (Selirand 1986; Roio 2007: 27). These areas were probably ideal locations to erect settlements so close to (or even in) the water (Hasenfratz & Gross-Klee 2005; Ismail-Meyer et al. 2013: 318).

Furthermore, previous occupation of similar sites could influence the subsequent choice of inhabit dwellings, according to the "cultural memory" perspective (Jennings 2014: 80)[1]; for instance, this is the case of the lakeside settlements reoccupied during the Bronze Age and Early Iron Age at the Circum-Alpine region, after a first Neolithic occupation. As firstly quoted by Schlanger (Schlanger 1992: 92) and improved by Cameron (1993), lakeside dwellings are, in some extent, "persistent places": the long-term occupation of this region had a complex alternated trajectory of occupancy and abandonment, a sequence of social decisions and dispositions that is attested in such life histories of places (Crumley 1995: 1177).

[1] For the relation place/landscape memory see Van Dyke & Alcock 2003: 5, as suggested by Jennings 2014: 80.

Although the majority of lake-dwelling settlements coincide with periods of favourable climate, lakeshores were even settled despite evidence of climate deterioration (Menotti 2009: 63). During a colder and damper climatic period, for instance, the lake-settlements in the south-eastern Baltic region (transition period between the Late Bronze and Early Iron Age) were occupied (such as the Luokesa sites (Pranckėnaitė 2014); however, they were inhabited in nearly all cases for only short periods of probably a few decades (Gackowski 2000; Pranckėnaitė 2014: 342).

While these factors, as climate and environmental morphology enabled lake-dwellers to occupy the proximity of the lakes, negative influence on the economy has been detected, looking at crop failures; this emerged for instance in the already mentioned communities of Lithuania of the 1st millennium BC, where livestock farming remained an especially important part of the economy compared to agriculture (Pranckėnaitė 2014: 342). This condition has been caused in particular by the alternation of cold and wet summers (Pfister 2001; Menotti 2009: 63).

Other reasons behind human occupation of wetland environments and lake-dwellings largely remain unknown (Jennings 2014: 80). The choice to settle a landscape activates several cultural formation processes that start from the organisation of space: a package of "structural or architectural elements" (Ellison 1975: 292–307, 1981: 417–21; Barrett et al. 1991; Brück 1999: 145) were built as immovable form of material culture (Brück 1999; Gerritsen 2003, 2008; Jennings 2012; Arnoldussen 2013; Jennings 2014: 88).

Through the analysis of different houses' life-cycles, such as the planning, the construction process, the occupation period (which includes all renovation, expansion and/or internal modification) and the final abandonment, their biography can be reconstructed (*Fig. 1.13*), in a micro-scale (single house) and in a macro perspective (whole the settlement). In the following sections, explanatory examples, that are not to be considered as fully exhaustive, given the breadth of the topic and the large amount of existing data, will be provided.

3.1 THE FIRST ANTHROPOGENIC INTRA-DEPOSITIONAL PROCESS: THE BIOGRAPHY OF HOUSES IN WETLAND CONTEXT

Once the choice to settle in a wetland landscape was made, the community needed to adapt the natural setting for them to successfully live in. They could modify flora mainly in three ways:

1) introducing or favouring edible plants,
2) opening up woods for animal husbandry and, at the same time,

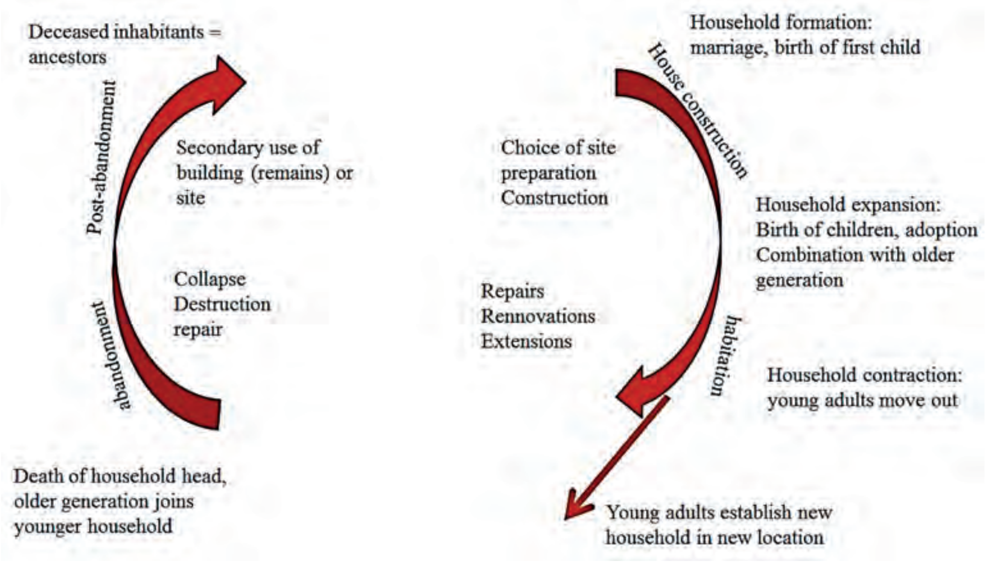


Fig. 1.13: The potential biography of a single-phase farmstead in northern Europe (from Jennings 2014, Fig. 5.5).

3) using natural resources such as wood for heating, building or producing metals.

Each of these scenarios would produce a characteristic vegetation pattern, whose traces should be found in the pollen and micro-charcoal record (Sadori et al. 2004: 11). Some changes in natural settings could involve the decision of building a settlement: the manifold use of wood implies a decrease of their presence in the environment due to the clearance of forests. This phenomenon is frequently followed by high values of anthropogenic indicators such as cultivated crops, new plant species, anthropogenic taxa and finally the enormous increase in microscopic and macroscopic charcoal concentration. This panorama is widespread in these case studies: a strong reduction of forest cover was observed in coincidence with the establishment of Late Neolithic pile-dwellings (such as Palù di Livenza, Northern Italy (Pini 2004) and Bronze Age settlements (Northern Italy: among others, Terramare of Tabina di Magreta (Bertolani Marchetti et al. 1988), Montale (Mercuri et al. 2006), Santa Rosa di Poviglio (Cremaschi et al. 2006) and the pile-dwellings of Lucone (Valsecchi et al. 2006; Badino et al. 2011), Ledro (zone LB3 during the Bronze Age) (Magny et al. 2009), Lavagnone (De Marinis et al. 2005), Tombola di Cerea (Martinelli & Leonardi 2015: 248), Bande di Cavriana (Zanon et al. 2019 and references therein); Central Italy: for instance the pile-dwelling of San Savino (Trasimeno Lake) (Angelini et al. 2013), Mezzano (Sadori et al. 2004) and Villaggio delle Macine (Chiarucci 1985, 1986–88, 1995–6; Angle et al. 2002; Zarattini 2003; Angle 2007; Angle et al. 2014; Achino 2016).

As a matter of example, the palynostratigraphic investigation of a pond record offshore to the village of Lucone D (Badino et al. 2011: 179) proved that this area was covered, before the settlement, by dense thermophilous broad-leafed forests (*Quercus, Carpinus betulus, Fagus, Ulmus*) replaced, through a sudden reduction in forest cover, by a strong increase of microscopic charcoal and the synchronous spread of several anthropogenic indicators (*Cerealia, Plantago lanceolata, Rumex acetosa, Trifolium*).

The cultural process of deforestation is also attested, during the Early Bronze Age, at ZH-Mozartstrasse (Menotti 2001b: 101), as well as at Bodman-Schachen 1 (Rösch 1992, 1993, 1996); during the Late Bronze Age the clearance was attested also at the site of Zurich-Alpenquai, as indicated by the presence of extended cleared areas and of grassland in pollen and macro-remains retrieved in the cultural layers of phase B (Jacomet & Brombacher 2009; Wiemann et al. 2012:80).

Nevertheless, aridity crises could even cause a natural deforestation, such as in the case of some Central Italy Bronze Age contexts: the 3800 varve years BP were characterised by this phenomenon well-known in many pollen diagrams from central Italy. This climate change could cause the human's local presence in the Mezzano Lake (Sadori et al. 2004: 16) between 3700 and 3500 years BP.

In Central Italy pile-dwelling of Villaggio delle Macine (Chiarucci 1985, 1986–88; 1995–6; Angle et al. 2002; Zarattini 2003; Angle 2007; Angle et al. 2014; Achino et al. 2016; Achino 2016; Achino & Barceló 2018), paloebotanical and ethnobotanical analyses (Carra et al. 2007) clarify some aspects of the natural setting that surrounded the settlement; the volcanic slopes of the Albano Lake, where the site is located,were covered by widespread broadleaf woodland (71%), predominantly oak, suitable to drained

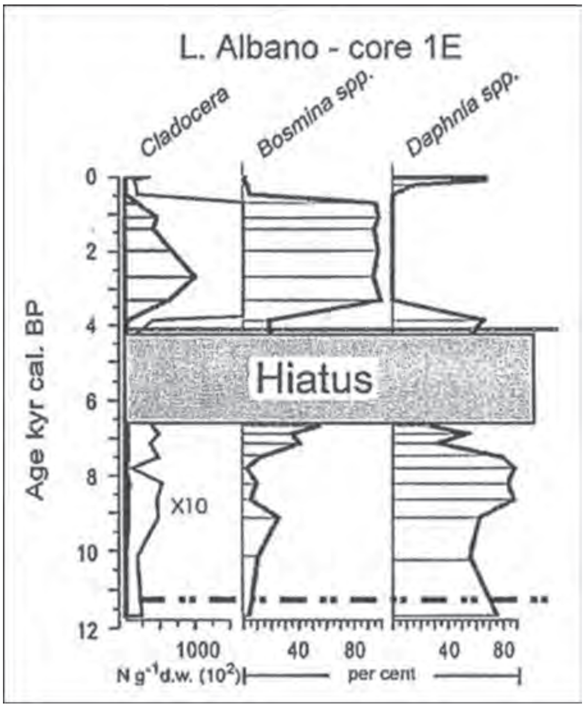


Fig. 1.14: Graphics shown the occurrence of deforestation in the studied area from the Albano and Nemi lacustrine records; this deforestation event is proved even by the shift from a *Daphnia*-dominated to a *Bosmina*-dominated community among the *Cladocerans* (*Anthropoda*) (from Angle, Sacchi, Zarattini 2011, 234–5, Fig. 9).

subsoils and a temperate climate (Angle 2008: 399). The brushwood vegetation is less attested and suggested that wet brush was rare. Neighbouring dry grasslands and the lacustrine environment – with a similar percentage of presence, ranging between 13–16% – complete the natural reconstruction. Taking into consideration such an environmental context, it is not surprising that a massive reduction of forest coverage, most likely caused by humans, was identified in correspondence with the earliest occupation phases of the settlement. At Albano Lake, the occurrence of this phenomenon is suggested by negative oscillations suffered by organic factors embedded in the sediment, which highlighted an oxidising environment with low aquatic productivity. Furthermore, an increase and predominance in non-tree pollen revealed the beginning of cultivation of edible fruit plants (Lowe et al. 1996; Rolph et al. 1996), as those attested at the site (*Rubus Fruticosus, Sambucus Ebulus, Nigra* and *Prunus Spinosa* (Carra et al. 2007). The increasing rate of sedimentation and the subsequent slope erosion testify to this deforestation event, supported further by a shift from a *Daphnia*-dominated to a *Bosmina*-dominated community among the Cladocerans (*Arthropoda*) (Guilizzoni & Oldfield 1996: 63–64; Ryves et al. 1996: 140; Guilizzoni et al. 2002) (*Fig. 1.14*).

The spatial arrangement of buildings might be decided during this stage: as majority of settlements have been only partially excavated, analyses related to the use of space are quite limited (Schlichtherle 2004; Ebersbach 2013: 291; Menotti 2012: 149). However, some general observations can be elaborated on the base of available data and thanks to the advance of archaeological investigations. The orientation of houses seems to follow patterns that have been varying across time and regions. For instance, Neolithic and Bronze Age settlements in northern Europe and Scandinavia differ considerably from those in the Circum-Alpine region (Menotti 2012: 149). The latter settlements tend to be more clustered and follow a regularised plan o semi-regular arrangement, such as settlements around Feder Lake, at Hauterive-Champréveyres and Cortaillod-Est, as well as the sites of Mozartstrasse and Kleiner-Hafner (Menotti 2004). Lake-dwellings on Constance Lake were erected along a road leading to the waterfront. While these Bronze Age settlements were constructed in rows, those of Federsee Lake (such as Siedlung Forschner and Wasserburg-Buchau) displayed conglomerates of buildings with small clusters separated from each other and all constrained by a surrounding palisade (Jennings 2014: 90). This latter structure may probably have been built so that the settlement did not appear particularly defensive in nature, or in order to impose a limit on the potential settlement size through the erection of perimeter palisades and fences.

Massive and/or protective palisades were also attested at the French lakeside settlements (such as Clairvaux and Chalain (in particular Chalain 19) (Pétrequin 1997, 1999), in Slovenia (such as at Maharski prekop where the settlement was protected by a double enclosure (Bregant 1974a, 1974b, 1975, 1996; Turk & Velušček 2013), at north-European wetland villages (as for instance Biskupin (Billamboz 2004), in some Italian lakeside dwellings (Lavagnone 2 (de Marinis 2000: 103), Fiavé 6 (Marzatico 2004: 87) and Terramare (such as, for instance, at Villaggio Grande of Terramara di Santa Rosa Poviglio, (Cremaschi 2010: 36) at Fondo Paviani, where a quadrangular earthen rampart surrounded the settlement (Nicosia et al. 2011: 281). At Greifensee-Böchen a surrounding palisade and "hedgehog-like" structure would have acted as both defensive measures and windbreaks. At the underwater pile-dwelling site of Sabbione, located on the western edge of the Monate Lake (Lombardy) (Binaghi Leva 2003; Poggiani Keller et al. 2011: 243) around 4000 piles have been identified, some of them related to concentric fences that mark the settlement towards the shore (*Fig. 1.15*), as observed also at Concise-sous-Colachoz (Neuchâtel) (Wolf et al. 1999). Dendrochronological analysis allowed to identify the gradual expansion of the housing area, characterised by the placement of fences progressively moved towards the dry land (Binaghi Leva & Martinelli

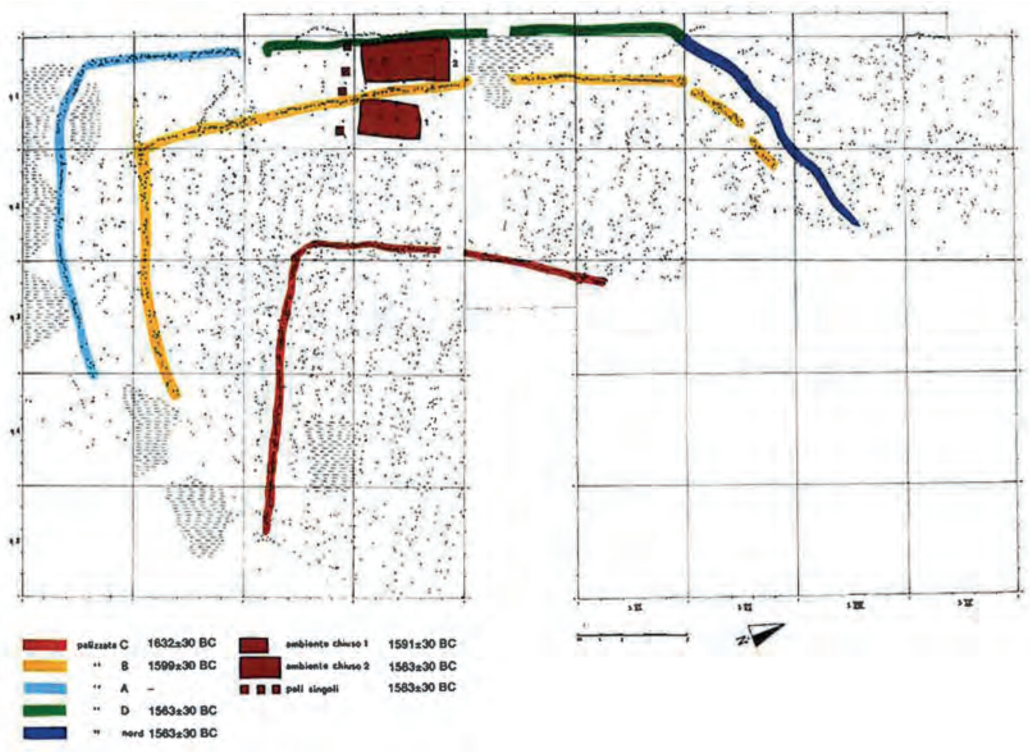


Fig. 1.15: Monate Lake, Sabbione (VA). Location of the fences ('palificata A-B-C-D') (from Poggiani Keller et al. 2011, 235, Fig. 1A).

2003; Martinelli 2003; Poggiani Keller et al. 2011: 243). Village expansion also involved the construction of some structures outside the surrounding palisade but within the hedgehog structure (Jennings 2014: 85). The settlements of Siedlung-Forschner stood out, as the 15 houses were protected by a massive wooden wall nearby them and a long and robust palisade a few metres outside the wall (Torke 1990 and references therein). The wooden fences, surrounding the site L1 of Luokesas, were not very solid and strong, although their height and type of construction remains unclear; this means that the purpose of defence was not of high priority, as the structure would most likely be aimed at preventing livestock from escaping (Pranckėnaitė 2014: 346, 351). Some fences were finally constructed along with settlements and they seemed to be easily and readily moved, disassembled and erected again, as at Suzt-Lattrigen (Ebersbach 2013: 290, 292, fig. 17.5). Their defensive features differ widely, from semi-circular structures built with thin sticks to real palisades.

Archaeological evidence indicates that Bronze Age settlements might have been more often fortified than Neolithic ones (Ebersbach 2013: 290–1). The sites where these defensive structures were not attested are in some cases referred to as "open" settlements, such as Ürschhausen-Horn (Jennings 2014: 91). Throughout high-precision dating of posts reconstruction of the whole settlement's development can be obtained: in response to a usual pattern one or two houses started in a given place, followed by few additional built in the next year. After two or three years a sudden increase of another ten or more new buildings can be seen, with some more houses being built in the adjacent areas. This pattern is attested, among others sites, at Arbon-Bleiche, Greifensee and Sutz-Lattrigen (Ebersbach 2013: 291).

The architecture of houses also varies across time and space, due to environmental and technological factors as well as cultural and regional reasons. As mentioned above, the natural pre-depositional layer consisted mainly of lake marl sediments; available on various glacial and morainic lakes, they are often in a liquid state, retaining thixosotropic characteristics similar to that of quicksand (Menotti 2012: 297).

Wooden piles of buildings got easily cutted into this type of sediments, since they are relatively solid until the vibrations of penetrating object liquefy them. This condition facilitated the penetration of object itself and sediments stabilised again once the vibration stopped. When the dry surface is removed or wetted with additional water, the entire process of driving a wooden pile 2–3 metres into the lake marl takes no more than ten minutes (Monnier et al. 1991:34, Menotti & Pranckėnaitė 2008: 3; Menotti 2012: 298).

This process can be even faster if sediments are particularly soft and inundated, such as in the eastern

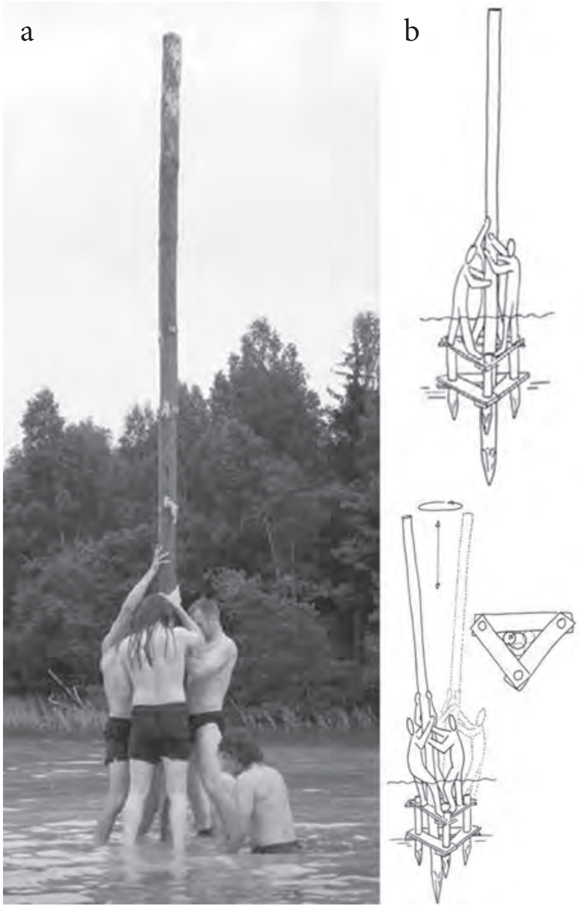


Fig. 1.16: a) The pile in vertical position with three people standing on the movable wooden structure, ready to begin driving it into the lake marl (from Menotti & Prankėnaitė 2008, Fig. 15a); b) Schematic illustration of the beginning of the experiment and the process of driving the pile into the lake marl (conical rotation, uplifting and dropping of the pile (from Menotti & Prankėnaitė 2008, Figs. 15b and 16).

Baltic Sea region; there piles were driven up to 4.5 metres into the lacustrine sediment, such as at pile settlements on Luokesas Lake (Menotti et al. 2005: 385; Menotti & Pranckėnaitė 2008) and in other European lakeside dwellings (such as at Fiavé (Perini 1987: 80).

Although there are various methods of driving wooden piles into the ground, the most common one is the rotate-lift-and-drop technique, as confirmed by experimental analyses based on material evidence recovered at the lake-dwelling settlement on Luokesas Lake (Lithuania) (*Fig. 1.16*). This was the technique mainly used in the lake-dwelling tradition of the Circum-Alpine region, during the Neolithic and Bronze Age.

On the contrary, in the case of peat sediments, driving wooden piles is a much harder task. Piles cannot usually be driven into the peat more than 1 metre-deep, even with the help of an initially excavated posthole (Menotti 2012: 297). It is therefore not surprising that the majority of houses found in peatbog environments (or shrinking lakes) were built directly on the ground (Schlichtherle 2004; Schlichtherle & Strobel 1999; Menotti 2012).

The process of adaptation to the environment involves also the choice of house architecture and its construction. For instance, while in a semi-wet marshland environment the community could choose between a pile-dwelling and a ground floor house, lakeshores could be only settled with pile-dwellings. These ancient architectural traditions of house construction are still adopted among present-day cultural groups: one of the best example is the pile-dwelling of Ganvié, on Nokouè Lake (Benin, Africa) (Pétrequin 1997). Here, people still live in traditional wooden houses, especially constructed on stilts. The resemblance of these modern settlements on stilts to the prehistoric European pile-dwellings of the Circum-Alpine regions is striking (*Fig. 1.17*).

Fig. 1.17: Contemporary pile-dwellings at Ganvié on Nokoue lake, Benin (from Pétrequin 1997, Fig. 128).

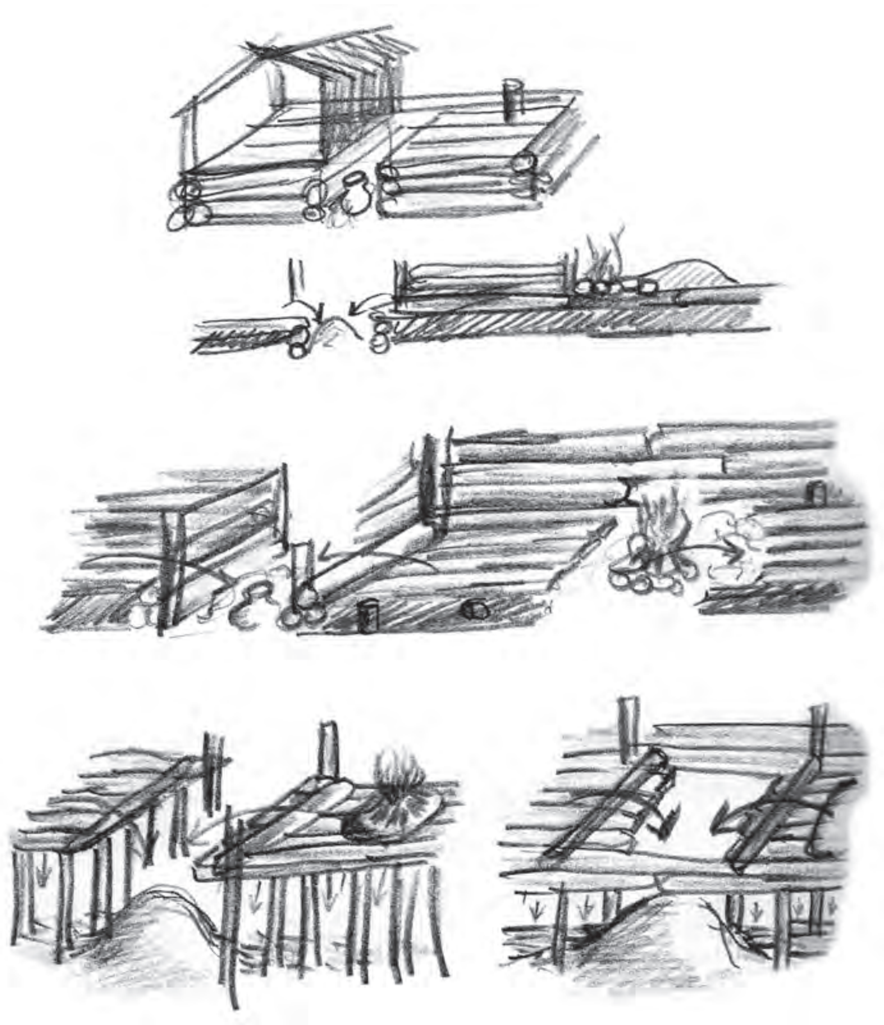
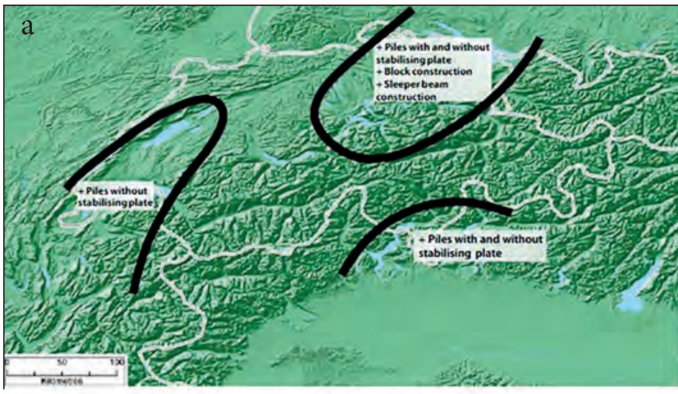


Fig. 1.18: Examples of some depositional and sedimentary models, related to different features of structures (from Balista, Leonardi 1996, 204, Fig. 4).

Lake-dwelling architectural types (pile-dwelling and ground floor houses) involve several construction techniques, which may vary according to their geographical location, chronology and the surrounding environmental conditions (Menotti 2012: 136). Different approaches were used to the foundation of buildings in order to compensate for marshy ground and topographic undulation: compact homogeneous loam floors could be laid directly on the ground with surrounding timber lintels. At the site of Lobsigesee and Cham-Eslen, they seem to have been connected to the perimeter of the houses. At Arbon Bleiche 3 they are combined with anthropogenic components (such as micro charcoal, ashes, fine organic material, charred macro remains and/or artefacts) (Ismail-Meyer & Rentzel 2004; Ismail-Meyer et al. 2013: 327). In other cases, grid-work timbers could be placed within the surrounding lintel structure to provide extra support for the floor (Jennings 2014: 83–4). At Greifensee-Böschen various degrees of stabilising methods were utilised: timbers or beams were secured together at their overlapping ends with treenails or binding. They limited the amount of movement that could occur within the structure itself. Furthermore, guiding piles were driven into the ground through pre-cut timber boards that served as weight spreaders for the above building structure (Jennings 2014: 85–6). For instance, the foundation of Fiavé 6, along the bank and on the bed of the Carera Lake, consisted of vertically pierced boards, i.e boards with holes for the allocation of the tie slats. They served to hold a grid foundation on the lake bottom and lay at right angles to each other, in order to distribute the weight of the huts that stood above in a regular manner (Marzatico 2004: 87–89). In other cases (such as in Austria, at the three settlements of Schärfling, Misling 2 and Weyregg-Landunfssteg) the compensation for the instability of the lake floor is realised through log frameworks, used as foundations of huts (Ruttkay et al. 2004: 51). Here, this framework is fastened to the lake floor with pegs. Other settlements displayed houses built on foundation frames and with floorings of perpendicularly set crossbeams, as in the French Jura (Chalain Lake) (Pétrequin 1991; Pétrequin & Bailly 2004: 36–45).

In Northern Italy a further quite widespread building technique is known, the *bonifica* (*Fig. 1.18*): this structure, built on the ground, could be stratified in one or more layers composed by vegetal elements and small wooden beams, according to environmental conditions. It is attested in some sectors of lakeside settlements as the exclusive building technique (such as at Isolino Virginia (Baioni et al. 2007; Ledro (scavi 1980–83), Lavagnone, Arquà (Balista & Leonardi 1996: 215–222), whereas in others it is also combined with pile-dwelling structures, as at Barche di Solferino, in the south-western sector of site (excavations of Zorzi and Nicolussi (Zorzi 1940) and Bande di Cavriana (Balista & Leonardi 1996: 215, 219). Moreover, for the northern Alpine region some scholars proposed a division between construction methods employed in western and the eastern part of the region and between the Upper Swabia and Constance Lake (*Fig. 1.19*). Houses found at Neuchâtel Lake (Geneva, Biel, Murten and Bourget) were constructed using piles driven into the ground and sediment which supported superstructures above the ground (Arnold 1990: 66–79). In some lake-settlements of western Switzerland, such



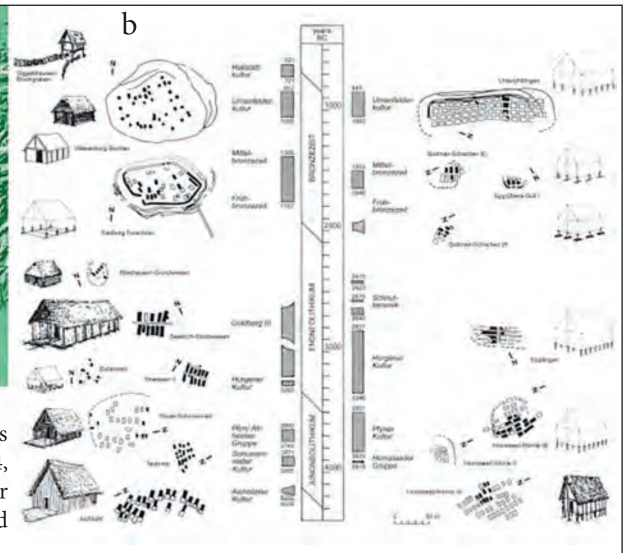


Fig. 1.19: a – Distribution of different lake-dwelling construction methods in Switzerland during the Neolithic and Bronze Age (from Jennings 2014, 81, Fig. 5.1); *b* – Cultural groups in the wetland communities of Upper Swabia (left) and Constance Lake (right). Dating, settlement plans and typical houses (from Menotti 2004, 28, Fig. 2.3).

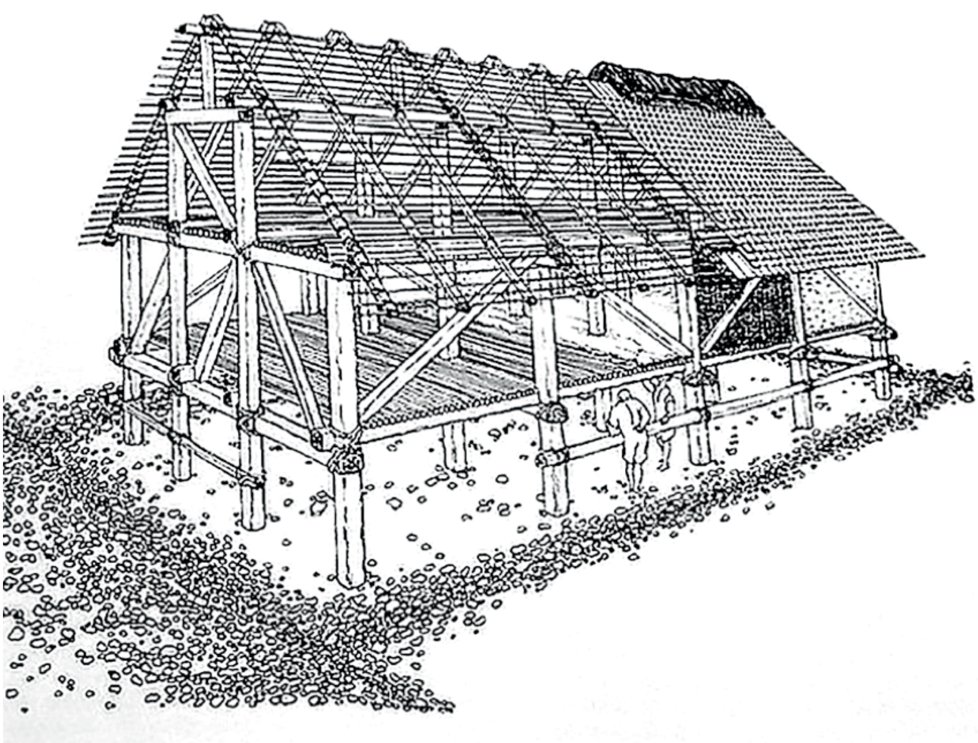


Fig. 1.20: Reconstruction of house from Cortaillod-Est (from Arnold 1990, 79, Fig. 69).

as at Cortaillod-Est, the three-aisle construction type was adopted, with four rows of posts (two wall posts and two internal posts) supporting the roof of the building, which measured up to 15.5 x 6 metres in width (*Fig. 1.20*). This three aisle plan cannot be observed in the eastern Switzerland (Seifert 1996: 168); houses were usually two-aisled with three rows of posts, the middle one being the ridge post row.

In the eastern part of the northern Alpine region, a variety of construction techniques has been identified, including piles driven into the ground through a stabilising plate (*Pfahlschue*); this perforated plate technique was used throughout the lake-dwelling tradition from the Neolithic to the Late Bronze Age (Ebersbach 2013: 28; Menotti 2012: 136, fig. 4.5b). Posts used as the main frame of houses at the Arbon Bleiche 2 seem to have been either directly rammed into the ground or inserted into a *Pfahlschue* or perforated base plate (Menotti 2001a: 104); for instance, in the sector A of Lavagnone, the Early Bronze Age (IB) dwellings rested on typical perforated wooden base plates (*Fig. 1.21*).

A construction method called *Schwellenbau* (sleeper beam construction) is attested between Constance Lake and Sempach Lake: piles were driven into the ground through boards or planks (Gross et al. 1987: 67; Seifert 1996: 168–71; Benkert et al. 1998: 199; Jennings 2014: 81); they provided stabilisation and support for buildings' posts and formed the bases and foundations of walls.

At the site of Zug-Sumpf buildings related to an earlier occupation phase (Seifert 1996: 46–53; Jennings 2014: 83) were constructed using the *Schwellenbau* and *Pfahlschue* techniques. Instead, more recent buildings were constructed using the block technique (Seifert 1996: 128–38). This block construction method, *Blockbau*, was common to the lake-settlements east and west of Constance Lake during the Late Bronze Age; this has been recognised at the settlement of Greifensee-Böschen (Greifen Lake, Switzerland) (Eberschweiler et al. 2007) and at Ürsch-hausen-Horn, Nussbaum Lake, Switzerland (Gollnisch-Moos 1999). This technique consisted of layering round timbers on top of each other that intersected and overlapped at building corners with notches or recesses, allowing timbers to sit flush against each other (Menotti 2012: 134; Jennings 2014: 81).

The block-building technique was also attested in the terrace houses of the fortified lacustrine settlement of Biskupin, in Poland, dated to the Iron Age (Menotti 2012: 144, Menotti & O'Sullivan 2013). A combination of various construction techniques is attested here, where block-construction, mortise and tenon joints were identified (*Fig. 1.22*). The most elaborate foundation system involved the raising of buildings on platforms constructed in a simple blockbau technique, with the insertion of floor timbers at an intermediary level of the structure (Gollnisch-Moos 1999: 21–71). Across the shore of Zurich Lake, at the Early Bronze Age ZH-Mozartstrasse lake-dwelling, wooden structures consisted of two superimposed groups of dwellings built on ground-joists. Both groups were directly built on the lake marl although, in the case of the second group, houses were also constructed on the old floor of the first. A plausible hypothesis about the function of such a massive and elevated floor is that it was built to protect dwellings from a possible lake level increase (Menotti 2001b: 100). Thanks to the well-preserved wooden structures it has been possible to attempt a fairly accurate reconstruction

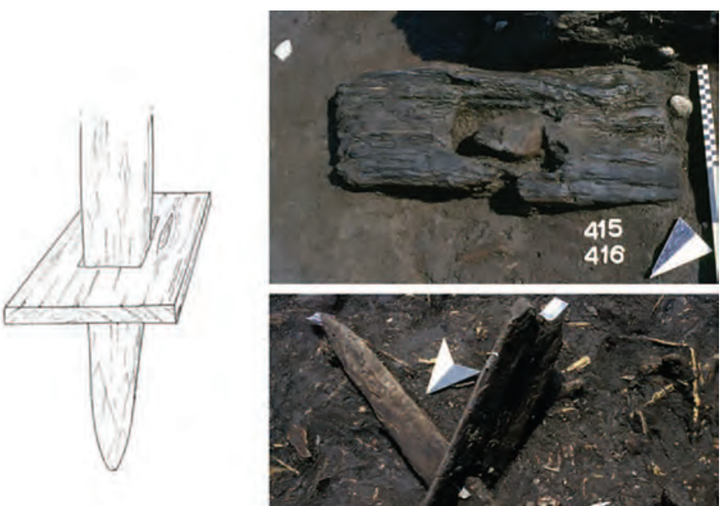


Fig. 1.21: Piles resting on perforated wooden base plates from sector A, Lavagnone (from de Marinis et al. 2005, 225, Fig. 5).

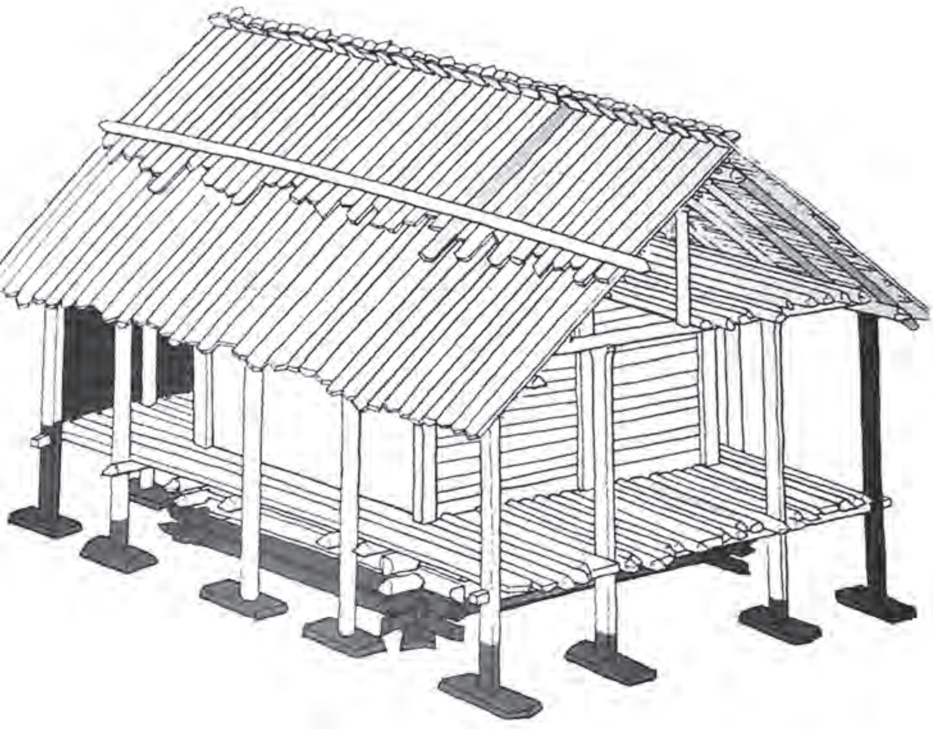


Fig. 1.22: Schematic reconstruction of the Late Bronze Age house of Greinfesee-Böschen, Greifen Lake, Switzerland (from Menotti 2012, 137, Fig. 4.6).

of houses (Gross & Diggelmann 1987a, 1987b; Menotti 2001b: 99). Furthermore, the Neolithic Egolzwil settlement provided an example of the packwerk technique where foundations have been created by packing assorted timber in a regularised cross-hatch pattern (Wyss 1983; Jennings 2014: 83). At the site of Hunte 1 (Dümmer Lake, Central Germany), three types of architecture can be distinguished in chronological order. The first and the oldest consisted of a peculiar polygonal hut, whereas the second and third are rectangular buildings varying in size. While the first two types seem to have been built directly on the ground, the third type could have been slightly elevated on stilts floors (Menotti 2012: 139). Although wetland house remains in Poland are not numerous, three regions showed distinction in terms of house architecture; in the Wielkopolska region a prevalence of vertical pile constructions is noted, while in the others (Masurian and Pomerania) houses seem to have been built on large platforms – not on stilts – constructed on top of artificially built islands in the water near the lake-shore (Menotti 2012: 140). Similarly, the Poggiomarino settlement was built in a marshy riverine environment (on the bank of the River Sarno, central Italy): a series of artificial islets with houses on top were constructed (Pruneti 2002; Cicirelli et al. 2008). A comparable structural model has been recognised in England, Scotland and Ireland where lake islands were made up and used for habitation, the Crannogs (O'Sullivan 1997, 1998; Cavers 2006; Henderson 2007; Henderson & Sands 2013).

Fens should also be included in this overview: they consist of drowned landscapes, overcome by wetland conditions only from the Neolithic onwards and occasionally an earthwork. It had once stood on the former land surface that became engulfed by peat, to be revealed many centuries later, when drainage and ploughing caused the peat to shrink and waste away (Coles 2004a: 101). Two basic methods of constructions have generally been suggested for fens. The first, the Packwerk model, consists of an artificial mound being built up, characterised by layers of material with one or more structures built upon; the second model shows a free-standing platform; there is evidence for both approaches in all countries (Henderson and Sands 2013: 274). These models are most readily identified in later Bronze Age Irish sites, which seem to present a greater range of constructional forms (O'Sullivan 1998: 69–96). For instance, at the Late Bronze Age phases of Ballinderry Crannog N 2, Ireland, both free-standing and Packwerk approaches are clearly found (Newman 1997: 97; Cavers 2006: 391). The primary construction of the Early Iron Age site of Oakbank crannog in Scotland seems to have been firstly free-standing and only subsequently becoming more of a Packwerk mound (Dixon 2004).

This overview cannot be exhaustive without the analysis of Terramare: as already mentioned, they can be defined as mainly quadrangular settlements sur-

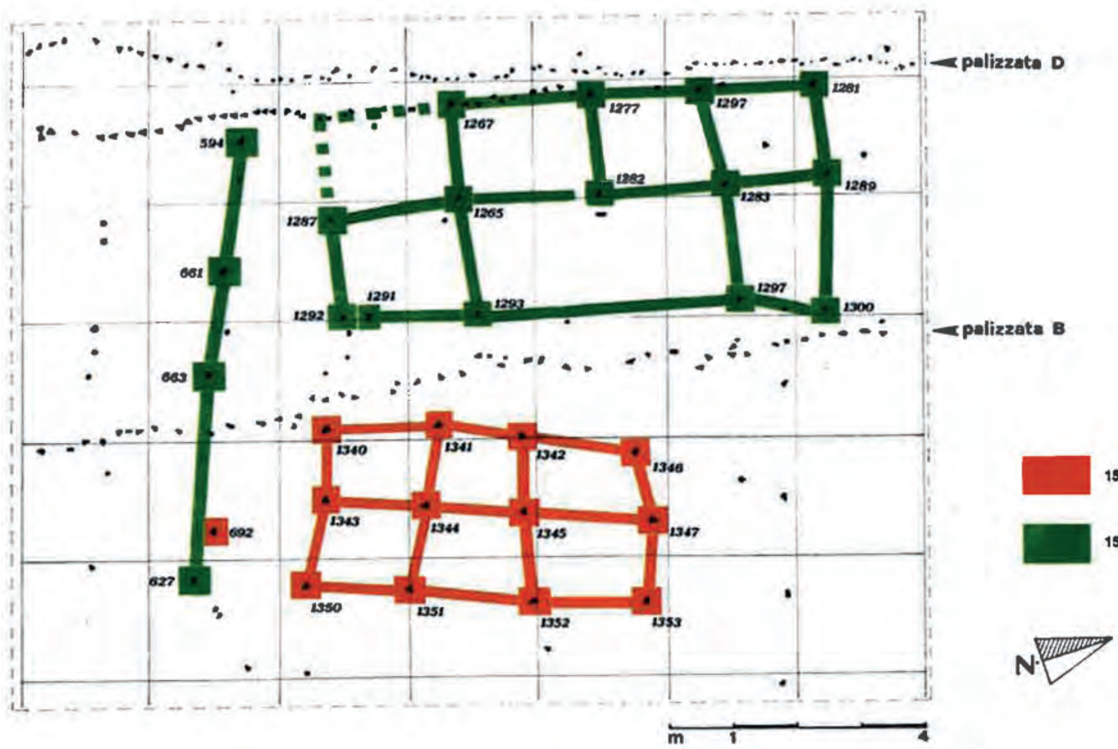


Fig. 1.23: Reconstruction of the houses from Sabbione, Lake Monate (from Poggiani Keller et al. 2011, 235, Fig. 1B).

rounded by an embankment and ditch into which waters of a nearby river or natural canal were re-routed. Thus, apart from performing a defensive function, earthworks also functioned as containing walls and as means to redistribute the water resources, as it has been attested, for instance, at Castello del Tartaro and in various other Terramare, including Santa Rosa and Redù (Modena) (Cardarelli 2010: 450). Generally, houses of the Circum-Alpine region and the Mediterranean (such as Dispilo (Hormouziades 1996) were similar in shape to Terramare, as they were rectangular. However, their size may still vary according to place and time. A standard pile-dwelling would normally not exceed 4 x 10 metres (such as Hornstaad- Hörnle 1A, Arbon-Bleiche 3 (4 x 8 metres), Poggiomarino settlement (3–3.5 x 10–12 metres) and they could be smaller (such as some on-platforms houses found at Moltajny (Poland) (3.2 x 3.5 metres) (Pydyn 2007: 325–7) and in Austria (at Schärfling, Misling 2 and Weyregg-Landunfssteg with houses of averaged 3–4 metres in length (Offenberger 1981; Ruttkay et al. 2004: 51). Two rectangular houses have been reconstructed at the pile-dwelling of Sabbione, Monate Lake, within an area of 120 m^2 including sectors III/01 and IV/01, thanks to archaeological underwater research and dendrochronological analysis (Poggiani Keller et al. 2011: 234); these two houses, with dimensions of respectively 3 x 5 metres and 4 x 8 metres, have been built between 1591 and 1583 cal BC (*Fig. 1.23*) (Binaghi & Martinelli 2003) and shown strict comparison with houses from the villages 1 and 3 of the Bodman-Schachen pile-dwelling (Constance Lake) (Köninger 1998). However, at Federsee a long-house (e.g. Seekirch-Stockwiesen) built directly on the ground would easily reach 5 x 15 metres (Schlichtherle 2004; Menotti 2012: 130); evidence of elongated pile-dwellings have been found at Humudu and Majiabang in China and in Japan where the Jomon rectangular houses of Ondashi reached 5 x 10 meters (Menotti 2012: 139). Across the Zurich Lake (in particular at ZH-Mozartstrasse), the size of the houses range between 5 and 6 metres in length and 3 metres in width, with the only exception of houses 5, 6 and 9 in group b which are one third larger than the others (Menotti 2001b: 100). Similarly, the dwellings with recognisable dimensions of the Arbon-Bleiche 2 had, according to Hochuli (1994), an approximate length of 4.5-6 metres and a width of 3.5–4.5 metres. In England and Scotland the shape of houses was circular (such as at Glastonbury or at crannogs). The majority of Neolithic lacustrine settlements out from the Circum-Alpine region such as La Marmotta (Bracciano Lake, Lazio, central Italy) (Fugazzola Delpino 1998, 2002) and La Draga (Girona, Catalonia, Spain) (Bosch et al. 2006; Palomo et al. 2014; Palomo 2017) seem to have been built directly on the ground. The floor of the latter type was usually made of various strata of round-wood, bark, twigs, plaster and it was

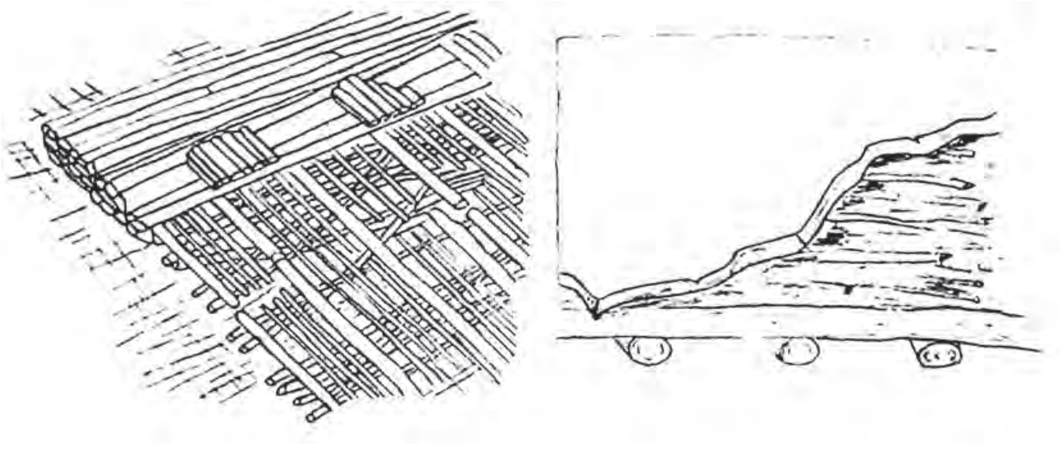


Fig. 1.24: Different kinds of lake-dwelling house floors, (left) multi-layered roundwood floor build directly on the ground; (right) wooden floor paved with clay (from Menotti 2012, 134, Fig. 4.3).

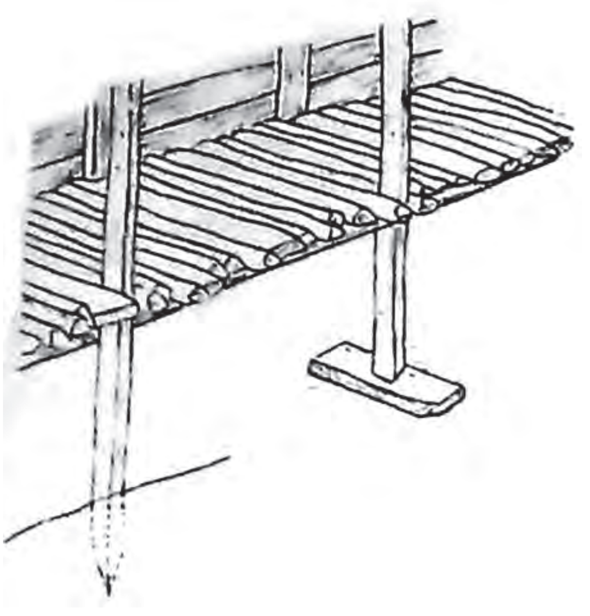


Fig. 1.25: Elevated floor of a pile-dwelling (from Menotti 2012, 134, Fig. 4.3).

sometimes covered in clay (*Fig. 1.24*). At the sector D of La Draga and in particular in the Level VII (the earliest phase of occupation corresponds to the level of collapsed wood), posts ending in a fork into which a plank was fitted in a clearly original position were documented. This association seemed to define a wooden structure that would separate the wet ground level from the level activity. This element is a direct archaeological evidence of use of wooden structures erected above ground level (Palomo et al. 2014: 65). Moreover, for the second phase of the site's occupation, the presence of travertine blocks attested the construction of a paved surface (Structure 252) which extends over the entire sector D (Palomo 2014: 62): this structure was documented in Sectors B and C still on top of the collapsed wooden level. Furthermore, the elevated floor of pile-dwellings consisted of half-split small logs or planks but they too were sometimes paved with a stratum of clay (the latter model was found at Fiavé 6 (Perini 1987). At Lucone di Polpenazze (Lucone D), the vertical posts were blocked with a pressed plaster composed by gravel and firm clay used as blinding agent, that surrounded the posts from 20–30 cm, within the bottom silt; this system could also be substituted by big stones used as basal plinth (Baioni et al. 2007: 89). At ZH-Mozartstrasse lake-dwellings, floors were mainly built of beech (Menotti, 2001: 100) (*Fig. 1.25*). The Bronze Age lakeside dwellings displayed a coexistence of different building typologies, with a remarkable capacity of adaptation to varying geomorphologic conditions, as attested for instance at Fiavé. There, in the Fiavé 6 settlement, dwelling structures in water on "individual piles" as well as ground-foundation structures were found.

A similar technique was employed at the site of Stagno (Livorno, Italy), in the area C. The remains of this structure consist of seven vertical elements (120 cm long and 30 cm in diameter), with a long point (50 cm ca) carved to facilitate insertion into the ground. Some of these vertical elements are still preserved in situ, planks passing through rectangular openings in the upper part. Perpendicularly to these planks, spars of 350 cm maximum length and 10 cm ca diameter, were placed horizontally. Some small vertical poles were even found and are supposed to have functioned as further side-supports for horizontal elements. On the whole, the structure appears to have been a well-anchored rectangular building with a peculiar level of small branches laid down in a compact manner, likely intended as a floor (Zanini 1997; Giachi et al. 2010: 1262). The same house construction technique was found at Lavagnone (Lavagnone 3), where upper parts

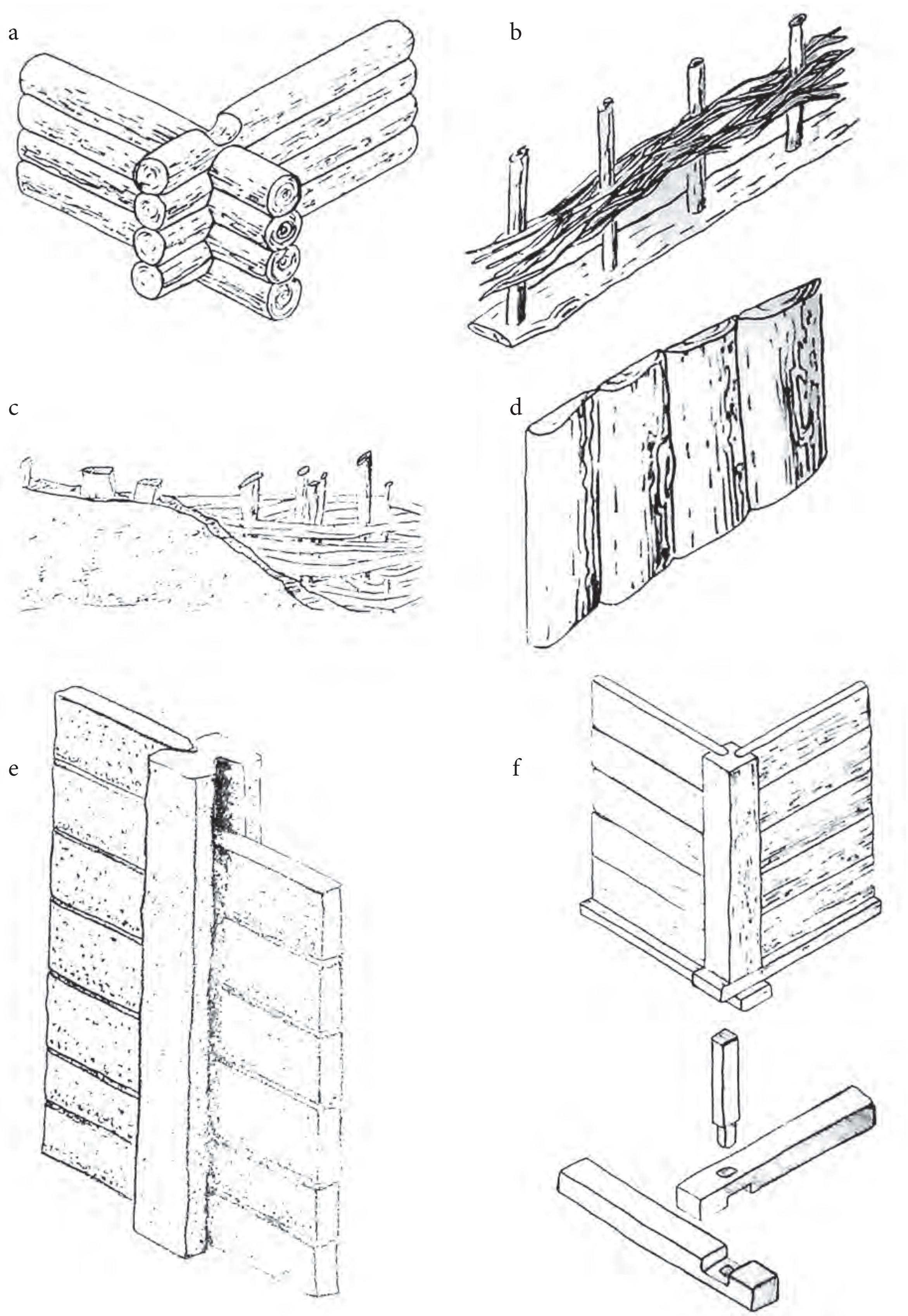


Fig. 1.26: Different kinds of lake-dwelling walls. a) Block-construction; b) Wattle; c) Wattle and daub; d) Split roundwood; e) Plank-pillar; f) Plank-pillar with mortise and tenon joints (from Menotti 2012, 135, Fig. 4.4).

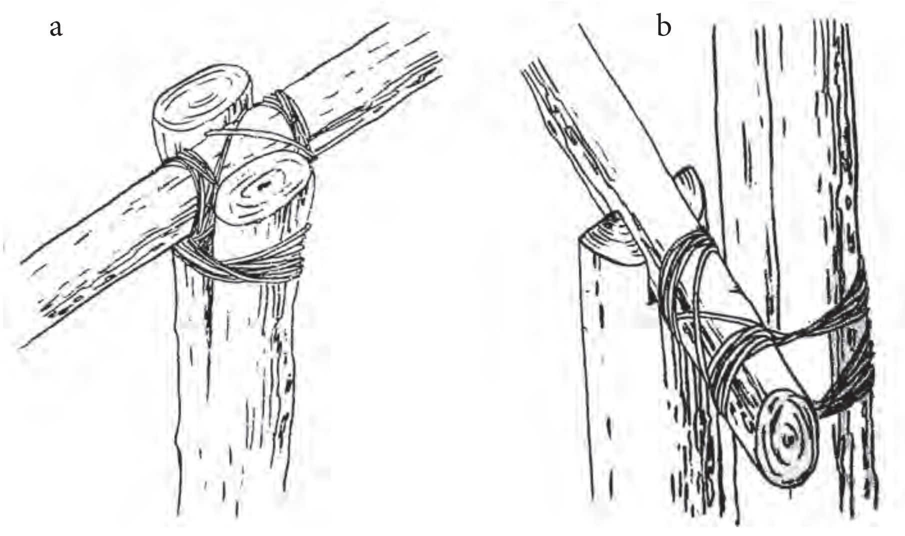


Fig. 1.27: The twin-pile building technique: long (a) and short (b) piles supporting the roof (from Menotti 2012, 137, Fig. 4.7).

of piles support the superstructure on brackets, differently from Fiavé (Perini 1987: 82). Recently, a relation between the construction methods of Fiavé 6 and those of the Early Bronze Age site at Bodman-Schachen in the western area of Constance Lake has been proposed by Köninger and Schlichtherle (Köninger & Schlichtherle 2001: 45; Menotti 2004: 89). In two Polish regions (Masurian and Pomerania) two different ways of preparing the ground for the on-platforms houses have been identified: a) the *Fascinenbau* (the area was prepared with irregular timber and brushwood) and b) the *Packwerkbau* (different strata of roundwood were used in order to construct a large platform which was the base layer of houses) (Menotti 2012: 140–141). At the site L1 of Luokesa architectural remains correspond to those of the artificially built wooden platforms in Poland (Gackowski 1995; Heydeck 1909; Pranckėnaitė 2014), but L1 has been identified as a pile-dwelling such as few Polish examples (Polanowo 12 and Powidz 16) (Pydyn & Rembisz 2010; Pranckėnaitė 2014: 348). The site is composed of buildings with raised floors, with cultural deposits accumulated below (Ismail-Meyer 2014; Heitz-Weniger 2014; Pollmann 2014). The construction technique of walls varies considerably, from simple half-split, vertically set small logs to block-construction or wattle-and-daub panels (Pétrequin 1984; Menotti 2012: 134) (*Fig. 1.26*). At the lakeside settlement of La Draga, preliminary data related to the construction techniques are available, although analyses of some elements retrieved in the sector D are still in progress. For instance, small calibre branches interwoven between them to form a lattice may have constituted parts of the walls; this type of construction technique is well-known ethnographically, where interlaced branches are then covered with clay. However, clay remnants were not associated with these elements at La Draga (Palomo et al. 2014: 64).

At MZ-Mozartstrasse the walls were mainly built of oak (Menotti 2001b: 100), such as at some contexts from the Slovenian region (Čufar et al. 2010), whereas at San Savino site they are of beech. At this site and at the Terramare of Montale (Mercuri et al. 2006: 53) the oak was used for pile supporting framework and roofs; traditionally, roofs are difficult to reconstruct as are usually not preserved. Wooden shingles were probably used more often, as straw and reed seemed to be not available in sufficient quantities in Neolithic periods (Jacomet 1997: 285). Also bark or combinations of different materials might have been used; houses with a ridge post row have surely had a gabled roof with its angle, depending on the covering: straw and red need steep gradients to let the rain drip off easily, while shingles can also be secured to low gradient roofs (*Fig. 1.27*). A steep, high raising roof could easily have been used as a second attic. Notched log ladders indicate the use of construction elements high above the ground (Ebersbach 2013: 287). At the Arbon Bleiche 3 and Fiavé 6 the roof was made of reeds or wooden shingles and in some cases also bark from different species of trees were attested; at ZH-Mozarstrasse they were mainly built of ash (Menotti 2001b: 100). As main cultural processes, e.g. the decision, planning and the settlement construction process have been summarised, this analysis will now address the occupation of houses and the material evidence of living floors.

3.2 THE LIVING FLOORS OF LAKE-SIDE SETTLEMENTS

Activities undertaken in the stage of habitation of a settlement are primarily related to the maintenance of "commensal" unit, including food processing, preparation and consumption, sleeping, manufacture and maintenance of tools/artefacts and the consequent maintenance of specific activity areas (Rathje & Schiffer 1982: 46; LaMotta & Schiffer 1999: 21). At the lakeside settlements, such everyday activities took place indifferently in most of structures (*Allzweckhäuser*) (Ebersbach 2013: 289). Sometimes, smaller buildings existed in, between or behind normal houses that were interpreted mainly as granaries or storage buildings; a late Bronze Age storehouse has been found at Wasserburg Buchau (Menotti 2004: 29). However, in most cases, size and position of houses are insufficient criteria to identify different functions: for instance at Greifensee no differences between big, central and smaller buildings alongside fences have been identified. Very few special houses, identifiable as workshops, have been found in most recent years, in particular in Bronze and Iron Age buildings, mainly related to metalworking (Hochuli et al. 1998: 206–7; Müller et al. 1999: 146–9). According to Ebersbach (Seifert 1996; Ebersbach 2002, 2013) the existence of stables, barns or workshops as separate buildings has not as yet been proved in any Neolithic wetland settlement of the Alpine ridge, although this is often stated in older publications. Nowadays almost no structures in wetland sites around the Alps could be interpreted as elite houses (e.g. houses of special wealth, size, building material or furnishing) or religious and/or political communal buildings or market places (Seifert 1996: 123–5; Ebersbach 2013: 290; Menotti & O'Sullivan 2013). Very few special structures recently have recognised and labelled as "cult houses" (Schlichtherle 2006; Honegger 2007)[2]: although their architecture does not differ much from other buildings of a settlement, they displayed certain artefact categories, special decoration of walls or particular orientation. At the site of Marin-Les Piécettes (Neuchâtel Lake), a central building was erected on an artificial little hill, with an unusual high number of posts and absence of artefact categories like stone, bone and antler tools (Honegger 2001; Loser & Maytain 2007). In the settlement of Reute, one house of bigger size and different orientation also showed a special distribution of artefacts (Mainberger 1998). At Luwigshafen house walls with painted decoration and modelled breasts occurred, alongside high-quality textiles, fishnets and anthropomorphic pottery (Schlichtherle 2006). Two earliest buildings of Greifensee, constructed in a central position and with a technology differing from the other, could show a special meaning; here, artefact categories such as food processing and textile production tools as well as low densities of remains were absent (Eberschweiler et al. 2007; Ebersbach 2013: 289). At ZH-Mozartstrasse an Early Bronze Age packwerkbau platform of 200 m^2 was found; some hypothetical functions have been suggested, such as central village place, a workshop, a herding or cult space (Gross et al. 1987: 70–74; Jenning 2014: 81). Since lakeside settlement buildings with a certain special function are very rare, most of these structures seem to have been devoted to domestic practices. Material residues of these activities can make their way into the archaeological record through three major depositional processes. The "primary deposition" (a) is the accretion process by which objects enter the archaeological record at their location of use, either through discard as "primary" refuse (Schiffer 1972, 1977, 1996) or through accidental deposition as "loss" refuse (Fehon & Schlotz 1978; Schiffer 1996: 76–9). Determining which objects could directly enter the archaeological record, an understanding of how the living floor of an ancient house was formed and consequently its penetrability is required (LaMotta & Schiffer 1999: 21). For instance, in the case of an elevated floor (a floor on stilts that can be made of round wood or planks and sometimes coated with clay), some of refuse consisting of numerous potsherds, animal bones, seeds and wood fragments could accidentally fall during the occupation of the structure, forming a dump; the underlying organic marl could have surrounded them. At Fiavé (horizon 6) complete pots of various dimensions, after settling upright or horizontally on the organic marl between the piles, had subsequently been fragmented by the weight of overlying deposits.

At Lucone di Polpenazze, in the excavated area A from the Early Bronze Age layers, some quite entire vessels recovered in the organic marl (layers G-H-I) probably fell down from aerial substructures of pile-dwellings (Baioni et al. 2007: 86). Elevated floors and the close proximity of houses in some prehistoric lacustrine villages of the Circum-Alpine region have always intrigued scholars as to where the daily waste was discarded. In order to shed more light on this issue, few experiments on refuse discarding have been performed (Menotti 2012: 315). Thanks to these reconstructions, the presence of a rubbish flap on the house floor has been hypothesised, since discarded waste was discovered underneath the elevated floor (Leuzinger 2000; Jacomet et al. 2004), such as at Arbon-Bleiche 3 (experimental reconstruction) (*Fig. 1.28*).

The concentration of poppy seeds found inside one of the Chalain station 3 houses might confirm this scenario (Baudais et al. 1997: 703; Jacomet and Brombacher 2005), since the disposal could have been realised through a sort of trap-door in the floor. First excavations carried out at Bande di Cavriana highlighted the presence of dump layers, held in place by wooden support elements, sometimes in the shape of boxlike structures, maybe comparable to those experimentally reconstructed (Piccoli, 1986; Zanon et al. 2019: **2**).

Furthermore, according to the reproduction of Unteruhldingen's houses (Constance Lake, Germany),

[2] As highlighted by some authors, their possible meaning or function remains open to discussion (Ebersbach 2013; Jennings 2014)

Fig. 1.28: A rubbish flap (rectangle) reproduced in the Arbon-Bleiche 3 experimental house (n. 23) constructed at the Pfahlbaumuseum, Unteruhldingen, Germany (from Menotti 2012, 316, Fg. 7.24).

lake-dwellers would discard their rubbish either at the back or the front of the house, depending on the location of the main street in relation to the house entrance (Ebersbach 2013: 314). According to Arbogast (Arbogast et al. 1997) in the rear of houses an empty space was presumably more "private". Usually, there were one or more fireplaces and sometimes also ovens built into houses.

Around the fireplace, all kinds of daily domestic activity have been identified, but only few remains survived, trampled into the floor; bigger remains have either been burnt or cleaned out. Thanks to experimental reconstruction of Chalain houses, more light was shed on the living conditions inside the house. For instance, a study of fireplace smoke in the house without a chimney was carried out: although it seems incredible, it was understood that the first 1,5 metres above the floor inside the house would not be engulfed by smoke, which would concentrate only in the upper roof.

Moreover, some advantages have been recognised, as the preservation of the thatch and the maintenance of the interior free of flies and mosquitoes in the summer and maybe even mice in winter (Monnier et al. 1991:20; Menotti 2012: 315). Detailed analysis of refuse patterns inside, below and around houses of Chalain showed also a more public space near the door, oriented towards the next open space, where rubbish heaps were often accumulated (Monnier et al. 1991; Menotti 2012: 315). As highlighted by ethnographic research (Murray 1980; Hayden & Cannon 1983), at most activity areas as well as at domestic spaces practices of refuse's cleaning up are periodically documented, with their spatial relocation elsewhere.

As mentioned above, also in the pile-dwelling context, any remaining primary refuse most likely includes objects that had a low potential for hindering on-going activities, especially objects small enough to escape cleaning technology (McKellar 1983; Tani 1995; Schiffer 1996: 66–7). The process of refuse cleaning up from the house floor or activity areas and its deposition in a spatially removed location (such in some middens, tofts, landfills and abandoned structures) (Schiffer 1972, 1977, 1996; see also Rathje & Murphy 1992) could display the depletion process or "secondary deposition" (b). Hence, at lakeside settlements refuse were predominantly accumulated outside houses forming dumps, probably in order to even keep a healthy environment.

For instance, in the sector D of Lucone a dump area, constituted of organic finds, fragments of pots and charcoals was found in the Early Bronze Age layers (Baioni et al. 2007: 90). In the synchronic layers of sector B of Lavagnone, waste dumps were found, serving as evidence of settlement activity (de Marinis et al. 2005: 223). At Isolino Virginia, in the layers of the third occupation phase a shallow ditch was found and interpreted as dump (Baioni et al. 2005: 211). At Hornstaad Hörne IA, on Constance Lake, the rubbish was especially thrown out houses. Remains of flax seemed to be concentrated only in a few places in the AH3 sector, in the organic layer 206, where rubbish zones of two houses overlap (Maier 2001, 70 Abb. 54). Flax remains were therefore not deposited everywhere in the settlement, but rather they were concentrated in certain places where other rubbish was also deposited; same observations were made on layer J at the site of Zürich AKAD/Pressehaus by Jacomet (1981, 137). On the contrary, at the much more recent site of Arbon TG Bleiche 3, flax remains were much more common and were found everywhere (Maier 2001: 79; Jacomet & Brombacher 2005). A rub-

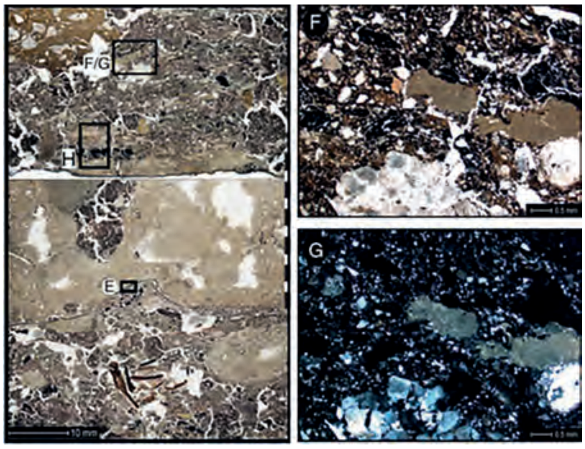


Fig. 1.29: Charcoal rich occupation deposit containing unburnt pottery manufacturing within a roofed area. Lobsigesee M6, PPL (from Ismail-Meyer et al. 2013, 328, Figs. 8 D, F, G).

bish heap in the back part of one house (C) was found at Chalain station 3 (Baudais et al. 1997: 725 ff), containing halzenut shells, carbonised cereal chaff, bones and artefacts. Charcoal and ashes were most likely formed close to hearths due to cooking; they were periodically removed and dumped in other locations, as confirmed by the density of plant remains. They were much lower near hearth structures, where dwellers cleaned regularly and rubbish was deposited in areas between houses (Jacomet & Brombacher 2005: 80).

In the mire site Alleshausen/Hartöschle, Maier found large amounts of carbonised cereals in the zone of the oven, suggesting that this was used for the handling and cooking of cereals. Concentrations of silver fir twigs were found at Horgen ZH Scheller in cultural layers inside houses; they were used as filling or insulation material (Favre 2002: 160; Eberli et al. 2002: 208). During settlement phases, horizontally complex deposits of variable compositions have accumulated, containing large amounts of preserved organic material (such as sand, carbonate mud, and some clay aggregates) as well as various types of biogenic remains (architectural elements as, among other, timbers, roof shingles, collapsed walls) and a multitude of artefacts and ecofacts (Röder et al. 2013: 16). Well-preserved organic remains are imbedded in this organic matrix, which also contains pottery and stone tools, charcoal, ashes, bones (including fish bones), loam aggregates, clods of lake marl and different dung remains, such as at Arbon-Bleiche 3 (Ismail-Meyer et al. 2013: 329). Organic remains accumulated on floors may be interpreted as waste from food processing and cooking (fruits, seeds, bones of wild and domestic animals, fish scales and bones, charcoals, and ashes), fuel (wood, bark, and twigs), and insulation (twigs, mosses, and bark residues) against humidity, wood working activities, animal stabling and other daily life activities (Ismail-Meyer et al. 2013: 335). Recent analysis performed at the site Zurich-Parkhaus Opéra proved that household waste was mostly dumped in a spot under the houses where the disposal of old hearth plates took place. The find concentrations, with mineral deposits, such as ashes, are associated with the loams and are located close to the centres of the buildings, together forming middens; their disposal most probably happened through an opening in the floor and has been identified still in place during excavation. Only rarely rubbish heaps were observed between the buildings (Bleicher et al. 2018: 39–40). "Special" accumulation referred to particular activity areas or practices are even documented; for instance, at Lobisgesee, very thin lenses of decalcified clay was interpreted as raw material deposits, due to their strong similarities with the matrix of ceramic sheds: they proved the production of ceramics in the living areas (Ismail-Meyer et al. 2013: 327) (*Fig. 1.29*). The distribution of pottery along the outside of buildings following breakage demonstrated by some ethnographic studies (e.g. Hayden & Cannon 198; Deal 1985) is confirmed in some lakeside settlement contexts: for example, at the settlement of Ürschhausen-Horn, ceramics were placed in such spatial location and fragments of individual vessels were dispersed among several structures (Gollnisch-Moos 1999; Nagy 1999; Jennings 2014: 85).

The activity of fireplace cleaning probably produced thick ash layers accumulated as a midden and found next to a house, at Stansstad-Kehrsisten (Ismail-Meyer et al. 2013: 330). For instance at the pile-dwelling site of Villaggio delle Macine (Achino 2016 and references therein) sub-quadrangular or sub-circular *concotto* (fired clay) slabs were recovered during all the later excavations, in some cases placed on wooden or vegetal elements and densely surrounded by fragmentary faunal remains and seeds, confirming the hypothesis that they were discarded in the area of their processing and potential consumption. The cleaning of these cooking areas following their use involved the formation of a charcoal- and ash-rich layer in surrounding squares. These cooking features shown different internal composition and shape: the sub-quadrangular one was predominantly composed of *concotto* and clay, while the sub-circular ones consisted of two compacted mud slabs surrounded by stones. This variability might mirror different cooking practices, following some ethnographic examples. Furthermore, combustion areas consisting of sub-circular hardened/compacted mud plates, sub-horizontally oriented, with a clayey-sandy composition, and rich in charcoal inclusions were also identified. During the 2009 surveys, a concotto slab with the imprinted negative of a spike was recovered. This discovery would confirm that corn roasting was carried out in these combustion areas (as proposed in Angle 2007: 403). These probably interrelated cooking-burning areas seem to be

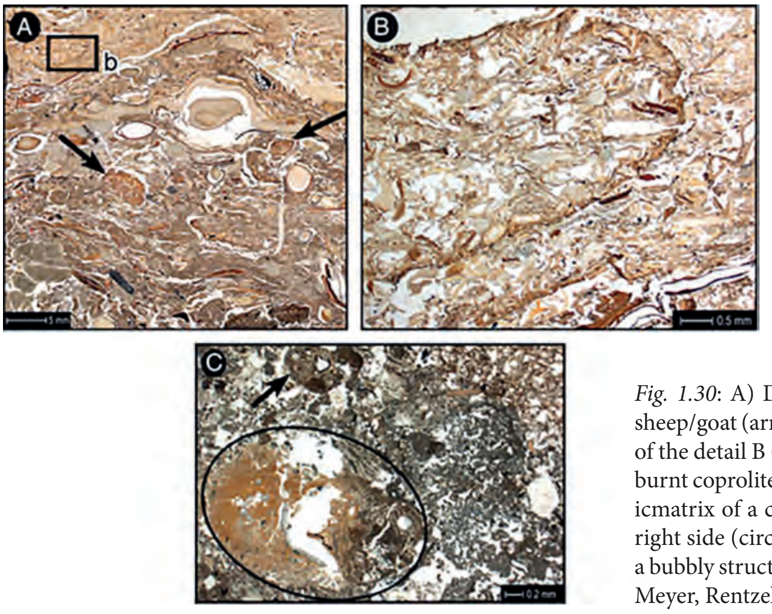


Fig. 1.30: A) Dung rich stabling deposit, with droppings of sheep/goat (arrows); B) the black rectangle marks the position of the detail B (Arbon-Bleiche 3 M1030); C) concentration of burnt coprolites withmelted phytoliths. The brown phosphaticmatrix of a carnivore coprolite turns into carbonate to the right side (circle). A further possible burned coprolite shows a bubbly structure (arrow) (Cham-Eslen M665) (from Ismail-Meyer, Rentzel, Wiemann 2013, 330, Figs. 9A–C).

spatially overlapping in different layers (as A11 and 18 respectively in Stratigraphic Units 6 and 11), suggesting a potential continuity of use for the same purposes throughout the site's occupation (Tagliacozzo et al. 2012: 146). It is also interesting to note that on the margin of the combustion areas above mentioned, medium and large storage and cooking pots were recovered, some of the latter bearing traces of fire exposure (Angle 2008: 403). The same storage purpose could be supported by a set of three *dolia* oriented according to the piles' North-South and West-East orientation and located in the northern sector of the area excavated during 2012. In addition, the remarkable presence of fruits, beans and cereals seemingly confirms this storage role of the area (Angle et al. 2014).

Furthermore, the high presence of specific refuse categories in some houses might suggest specialised practices: for instance, at Arbon-Bleiche 3 high proportions of wild animal bones in two houses were attributed to specialised hunting (labelled hunter houses) (Deschler-Erb/Marti-Grädel 2004: 232, 251) implying professional hunting (Röder et al. 2013: 25). At the site of Zurich-Alpenquai the high quantity of hazel twigs into the reduction horizon 1.1 (Q651) could be interpreted as a storage brought into the settlement during spring as food for humans and livestock; anyway, the layer could be also a dung layer (Wiemann et al. 2012: 73). At the Neolithic pile-dwelling settlement of La Draga, within sector A a concentration of malacological remains in varying transformation stages was documented (such as some polished *Spondylus* sp. remains) and interpreted as a small workshop specialised in the manufacture of ornaments (Verdún-Castelló et al. 2019: 75; Oliva 2015). Other special activities such as butchering have been attested in some contexts such as Horgen (Zurich Lake) and Sipplingen (Constance Lake) (Menotti 2012).

Furthermore, small wattle constructions were identified in some lakeside settlements; they could be used as enclosures for small ruminants. Leafy branches and mistletoe can be regarded as fodder for livestock that very likely resided within settlements, at least temporarily (Ismail-Meyer & Rentzel 2004; Ismail-Meyer 2010). Areas with dung layers interpreted as cattle stands have been found in settlements, located predominantly outside houses. However, rare finds of animal faeces in, under or between some houses document the presence of animals inside settlements and even within a house (e.g. Pestenacker, House 1: Schönfeld 1991). At Arbon-Bleiche 3, coprolites can be attributed to ovicaprids (sheep/goat), cattle and less frequently carnivores/omnivores (dogs or foxes and pigs), small rodents, possibly field mouse and humans (Le Bailly et al. 2003; Le Bailly & Bouchet 2004) (*Fig. 1.30*).

At the site L1 of Luokesas, beside dung remains, very few animal bones, mostly of sheep, goat and pigs were found, showing that livestock was kept at the site (Pranckėnaitė 2014: 348). In the mire site of Seekirch-Stockwiesen in the Federsee region, rubbish heaps including dung and human coprolite-zones were found beside houses (Maier 2004, 91–95).

One of coprolites investigated at Arbon Bleiche 3 appeared to be of human origin because its composition differed markedly from the ruminant coprolites and showed similarities with plant remains found in pot-crusts (Kühn & Hadorn 2004; Martínez Straumann 2004). It was composed of many bone fragments and remains of cultivated plants. There was a lot of cereal pollen and bran, remains of linseed and some apple-pericarps (Jacomet & Brombacher 2005: 80).

At Arbon-Bleiche 3 the combined results of micromorphology, the analysis of botanical macro remains and pollen studies showed that the ruins of a house were probably reused as a stand for cattle and sheep/goats in particular during the winter, as only dung dated to this season was found (Ismail-Meyer & Rentzel 2004; Akeret & Rentzel 2001; Kühn & Hadorn 2004; Haas 2004).

The same data, obtained from combined archaeobotanical investigations of sheep/goat pellets, seeds, fruits, vegetative plant material and twigs could be identified at the site of Fiavé Carera, in the Early/Middle Bronze Age layers (sounding 3, zone 4, stratigraphic units 3/12 and 3/20). It can clearly be shown that animals were kept inside the settlement area during winter/early spring (Karg 1998: 93).

The third major depositional process occurring during the habitation phase is provisional discard (c); in this stage, broken or worn-out objects are not discarded *per se*, but are stored or cached with the expectation that they will serve an useful purpose later (Hayden & Cannon 1983; Deal 1985; Schiffer 1996: 99; LaMotta & Schiffer 1999: 21–22). An additional contributor to provisional refuse is functionally obsolete items-broken or still usable – that are nonetheless retained instead of discarded. Can we attribute this "nostalgia effect" (Gould 1987: 149), e.g. the decision to keep items that took part in earlier activities in their own lives, to the potential re-use of timber (over repairs, expansion and/or internal modification of houses during the occupation or from other settlements)? Sometimes old items acquire a renovated function as a part of displays (Schiffer 1996: ch. 3). The construction of pile-dwellings would have required high amounts of timber that would have been used for construction of the superstructure. They may have constituted a significant and readily available timber resource which, in light of the current dendrochronological evidence, does not appear to have been extensively utilised (Jennings 2014: 104). Timbers of the initial pioneer construction have been reused at the settlement Conjux-Le Port 3 (Billaud 2011) and at Hauterive-Champréveyres, where evidence indicates that piles were occasionally removed and possibly reworked (Pillonel 2007:70). This re-use of timbers, coupled with the splitting of them to produce multiple piles from single logs, may indicate an over exploitation of the surrounding forest resources, leading to a reduced availability of suitable size trees; this condition was attested also at Cortaillod-Est (Arnold et al. 1986).

The material evidence of these structural changes and expansions can be found in anthropogenic layers: small aggregates of unburnt clay characterised by organic temper might be the only evidence of wall construction of raised houses, as in Arbon-Bleiche 3 and Standssad-Kehrsiten (Cammas 2003). Differently, accumulations of branches, wood, bark, moss, mistletoe, leaves and pine needles might derive from the preparation of timber for construction/re-construction activities and they could also be insolation material for the floor (Pétrequin 1997). Furthermore, the presence of clustered burnt loam fragments most likely indicate demolition and/or renovations of hearths (Ismail-Meyer et al. 2013: 327), as observed also at Zurich-Parkhaus Opéra where the amount of clay per loam structures, associated with baked fragments of former surfaces and loam patches indicate that these latter were remains of hearths episodically repaired, according also to the presence of mineral deposits, such as ashes. The organic bands between loam layers obviously represent deposition between two events of hearth restoration (Bleicher et al. 2018: 39–40). The renovation or reconstruction practices are often caused by environmental as well cultural processes: both fire events and water level variations have influenced occupational strategies carried out during the past by wetland dwellers; in some cases they have caused even the lakeside settlements' abandonment.

3.3 FIRE EVENTS AS EXPRESSION OF NATURAL PROCESS AS WELL AS ANTHROPOGENIC ACTIVITY

During the sites occupation phase, intentional (Chabanuk 2008) as well as accidental wooden house conflagrations happened quite often. These events have frequently occurred, in particular during dry phases, such as in the summer, with major sources of combustion being human activities and lightning (Van der Valk 2006; Lindsay 2010). Large amounts of ash were produced by surface vegetation of a peat which have easily been washed away by rain (Charman 2009; Lindsay 2010). Micromorphological analyses of building structures in some lakeside settlements have shown traces of combustion, confirming that fire management was fairly problematic, especially during dry phases. At the site of Cham-Eslen (Zug Lake) traces of conflagrations have been found in organic layers, as burnt plant material, ashes and melted phytoliths (*Fig. 31*); layers of charcoals were rather rare, as they are easily dislocated (Macphail et al. 2010).

At Arbon-Bleiche 3 and Stansstad-Kehrsiten the formation of fire debris from raised wooden dwellings were always associated with the collapse, tilt and displacement of affected structures (Hochuli et al. 1998). This has led to the formation of heterogeneous accumulations of burned daub aggregates, containing charcoal and ashes (Ismail-Meyer et al. 2013: 333).

Since the distinction between a structure purposely set on fire and one burnt accidentally is extremely difficult, some house-burning experiments have been

Fig. 1.31: E) scanned thin sections and description of micromorphological phases and their possible reconstruction; small rectangle marks the position of F) detail of a burned clay aggregate with melted quartz grains (arrows) and gray ashes at the bottom (Cham-Eslen) (from Ismail-Meyer, Rentzel, Wiemann 2013, 322, Figs. 3E–F).

carried out, in order to help the reconstruction task of archaeologists. In Denmark during the 1960s a replica of a full-scale Iron Age house was set on fire and the entire destruction process was thoroughly recorded (Hansen 1966; Nielsen 1966); the data obtained were corroborated by an unplanned conflagration that accidentally destroyed two large, full-scale LBK houses replicas at the Archeo-Centre in Netherlands (Flamman 2004; Menotti 2012: 315–6). Following a careful consideration of remains from both experiments (the planned and the accidental fires), archaeologists came to some conclusions: first of all, they recognised how easily and quickly even a quite large house can be destroyed by fire and, second, that even with a careful pre-and post-conflagration recording of data, the remaining archaeological evidence is very limited. Then, these experiments showed how construction elements and techniques of a house have direct implications on the way the house burns and collapses and their deep analysis can facilitate the full reconstruction of building techniques and material used; nevertheless, in most cases, also the experimental reconstruction shed less light on the different manner in which conflagrations took place during the past.

At the site of Zurich-Alpenquai a fire event was recognised in the cultural layer of phase B (layer 2.1): it contained little organic material, chunks of loam, wood, a relatively large amount of charcoal but also burned pottery and a clay-ash mixture on top of the layer. These latter suggested the presence of a burning event (Künzler Wagner 2005: 14).

At the site of Dispilo (Karkanas et al. 2011: 109) differences could be observed in the level of the destruction layer: these have probably to be attributed to the taphonomic history of burnt houses. Indeed, not all of them collapsed at the same time after the burning episode. Some of them may have fallen *en masse*, giving the impression of *in situ* wooden structures on the ground. However, sedimentary features clearly show that these structures had fallen into the water, as suggested by timber pieces which were half-burnt, burned only on the outer surface or on one side.

At Lucone D an extended well documented fire event left evident traces on the top of the archaeological record: the house has been completely burnt and its structural elements have collapsed, as the partially-charred timber beam found *in situ*; the settlement has been suddenly restored, with the installation of new posts and this event has been dendro-chronologically dated to around 1970 BC (Martinelli 1996; Baioni et al. 2007:89–90; Badino et al. 2011: 179).

Among other possible causes of the building or the whole settlement renovation some environmental changes can be listed: water level variations are likely to have triggered the decision of building certain house models rather than others. In addition, sometimes the lake level may have forced dwellers to abandon their houses, or it may have only indirectly influenced their lifestyle, through negative impact on the subsistence and economy (e.g. crop failure).

3.4 NATURAL INTRA-DEPOSITIONAL PROCESSES

3.4.1 LAKE-LEVEL FLUCTUATIONS

Climate is not stable in time. It is understood that long term as well as short term variations in climatic conditions might have influenced human occupational patterns in prehistoric and also more recent times (Menotti 2001b: 117). The reconstruction of past lake-level fluctuations is carried out through the study of sediments accumulated in lacustrine basins; the recognition of the water depth of past deposition environment and thus the definition of bathymetric markers are needed. In order to reconstruct past changes in lake levels of the sub-Alpine area, two methods have been used (Magny 2004a: 135). The first, established by Digerfeldt (1988) and used by botanists, is based on changes in the distribution of lake vegetation. Macrophytic vegetation is largely determined by water depth, resulting in a characteristic zonation of emergent, floating-leaved and submerged vegetation from the shore to the deep water. Changes in vegetal macrofossil assemblages in a sediment core can be assumed to reflect variations in the water depth at the core site. The second method, developed by sedimentologists (Brochier & Joos 1982; Moulin 1991; Magny 1992a, 2004), is based on a combination of multiple parameters, including changes in sediment texture (coarser deposits correspond to near-shore areas), lithology (organic deposits often characterise shallow water) and assemblages of various carbonate concretion morphotypes. Since modern studies have revealed that differences between these latter characterised specific zonation from the shore to the deep water, changes in their relative frequency can provide indications of past lake-level fluctuations. Other markers can also be used to reconstruct past variations in water-levels, for instance diatom, chironomid or oxygen-isotope analysis (Berglund 1986; Magny 2004a: 135). Lakes' hydrological balance is delicate, since climate alterations involving an increase in humidity and higher percentage of precipitation could have influenced this equilibrium, causing water levels to fluctuate (Menotti 2001b: 119). However, not all lakes react in the same way to climatic oscillations. An important role is played, according to Magny (1992, 2004 among others), by the sensitivity of lakes, mainly linked to the ratio of the catchment area to the lake area. The geological as well as morphological structure of the basin area, in addition to natural origins of lakes, the size and the length of their inlets and outlets, influence the intensity of a transgression. As a result, it is possible that during same climatic variations one lake records lesser or weaker transgressions than another lake situated nearby. For instance, despite Constance Lake and Zurich Lake form part of the same microenvironment and have similar geological origins, their response to hydrologic changes due to climate is not totally equivalent. This is mainly because of their difference in size and the extent of their catchment areas (Menotti 2001b: 122).

Furthermore, Magny (Magny 2001: 135) suggests that only synchronous changes in several lakes within a region can testify to their climatic origin. In order to reconstruct Holocene water-level fluctuations in a large number of lakes, possible correlations between variations in climate and the history of Neolithic and Bronze Age lake-shore villages have been tested. The data, from 29 lakes in a mid-European region composed of the Jura Mountains, the northern French Pre-Alps and the Swiss Plateau, indicate that the whole Holocene period was punctuated by alternate higher and lower lake level phases (*Fig. 1.32*).

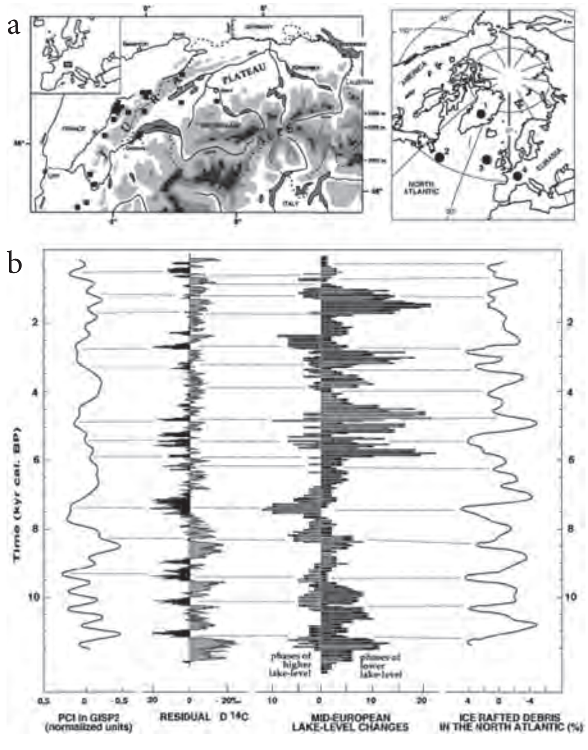


Fig. 1.32: a) Geographical location of the records presented in the lower panel; b) comparison between the Holocene record of the atmospheric ^{14}C variations (Stuiver et al. 1998) and the Mid-European lake-level fluctuations (from Magny 2004a, 136, Fig. 9.2).

Testing its climatic significance and implications, this mid-European lake level record is compared with three other palaeoenvironmental records and also atmospheric residual ^{14}C variations' diagram. In effect, since an attempt of correlating some of the French Jura lake levels fluctuations with the variation of the atmospheric ^{14}C content of the past 10,000 years has successfully been made by Magny (1995), the important role played by the solar activity has been recognised. In *Fig. 1.30* close correlations appear between the mid-European lake level record and the other proxy data (Magny 1999, 2004: 138). They display synchronicities with paleoenvironmental and archaeological data from these and also other European countries (van Geel & Renssen 1998). Magny (1995, 2004; Menotti 2009: 62) shows that there is a plausible correlation between climate and lake-dwelling occupational patterns (*Fig. 1.33*).

Pétrequin and Bailly (2004), on the other hand, argue that the relationship between climate and lakeshore occupation does not always work. There are in fact periods when climatic conditions in the lacustrine environment were favourable, but lakeshores were not settled. For

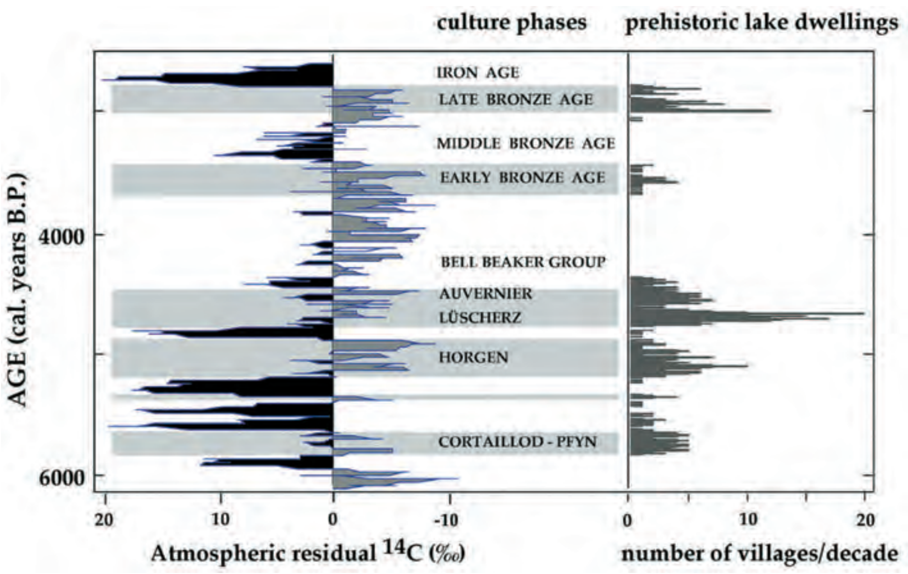


Fig. 1.33: Correlation between atmospheric residual ^{14}C variations (+unfavourable climatic conditions; -favourable -climatic conditions) and lakeshore settlement occupations in the western part of the Circum-Alpine region (Menotti 2009, 62, Fig. 1).

instance, short-term deteriorations in the climate during the first half of the 37th and 36th centuries BC had little impact on lakeshore occupation. On the contrary, in the 34th century BC some lakes, in particular in the western part of Switzerland, continued to be occupied, despite climate deteriorations (Menotti 2009: 62). During the Neolithic, in addition to one occupational gap that occurred over 3400–3250 BC, other interruptions due to transgression of lake levels have occurred in the entire northern Alpine region, displaying a more regional nature. Despite these local discrepancies, all occupations followed a general pattern, which matches with environmental factors and in particular with climatic conditions (Magny 1992b). The situation was slightly different during the Bronze Age and a sharp distinction has also to be made between the northern and the southern parts of the Alps. In the former, two main occupational gaps have occurred during the 24th–18th centuries BC and between the 15th–12th centuries BC. Since during the Early Bronze Age the northern as well as the southern part of the Alps were characterised by stable and favourable climatic conditions without indications of deterioration, this first gap in the northern region was indeed mainly due to cultural factors that have not affected, for instance, northern Italy and Slovenia, were lakeshores were kept on being occupied (Menotti 2001b: 119). On the contrary, towards the Middle Bronze Age climate started to deteriorate in both regions although this condition has reached the southern Alpine area at least one century later and its impact on lacustrine settlements occupation patterns was not so drastic. Some lakes are known as the most sensitive in northern Circum-Alpine region such as Constance and Zurich Lakes. At the former, normal seasonal level-fluctuations vary as much as three metres between winter (the lowest) and early summer and/or early autumn (the highest).

This natural phenomenon has also been witnessed on less sensitive lakes and even on shrinking morainic lakes such as Feder Lake (Siedlung-Forschner) in Germany (Schlichtherle & Wahlster 1986) and the former Carera Lake (Fiavé) in Italy (Perini 1987). Although not all sites were affected in the same way by water transgression, the extent of its influence on lacustrine settlements could depend also on the typology and the location of dwellings (Menotti 2001a, b; 2009). Indeed, it has influenced the way houses were constructed – reconstructed (Pétrequin 1984; Menotti 2001a: 319). A variety of house types, developed throughout the lake-dwelling tradition in the Circum-Alpine region, was ranging from houses on stilts on shores of highly dynamic lakes (with marked seasonal lake-level fluctuations, e.g. Constance Lake), to dwellings constructed directly on the ground (but nevertheless carefully insulated, e.g. Feder Lake) in wetland environments less prone to periodical floods (Menotti 2001a, 2004b; Schlichtherle 2004; Menotti 2012: 119).

Furthermore, since the cyclic nature of fluctuations have threatened lake dwellers, they have taken some measures to protect the house and settlements. For instance, during the Early Bronze Age phases of occupation at the lacustrine settlement of ZH-Mozartstrasse, houses were constructed directly on the soft ground with a single-layered wooden floor; in particular, a thick multiple-layered structure, which elevated the living floor by several centimetres, was found in a house built during the last phase of settlement occupation, probably in order to protect houses against rising lake levels (Gross 1987; Gollnisch & Seifert 1998; Menotti 2001b: 100).

Nonetheless, these water-level transgressions have influenced and damaged occupational layers of dwellings. Generally water fluctuations could quickly inundate and covered by fine-grained deeper water deposits (lake marl), or, if the water had risen slowly, its effects

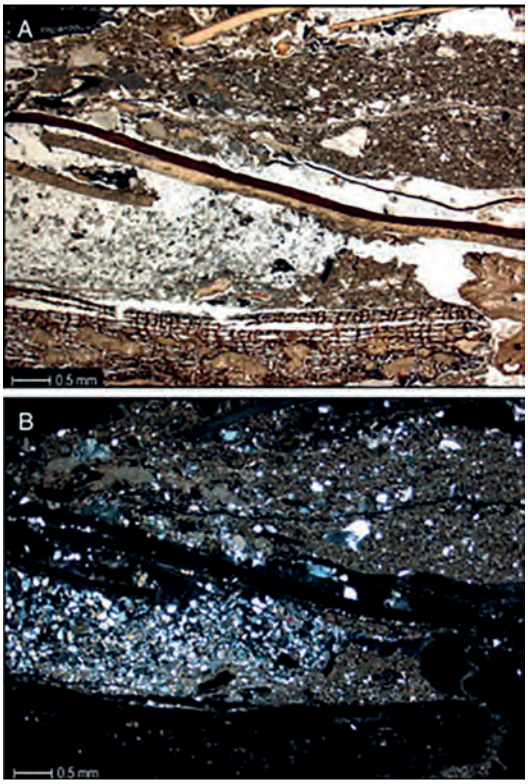


Fig. 1.34: A) Sorted sand deposit on a top of an erosion surface as a consequence of a sandy inwash from the hintherland. Note also the homogeneous transgression deposit in the upper section. Arbon-Bleiche 3 M1036, PPl. B) Same as A, XPL (from Ismail-Meyer, Rentzel, Wiemann 2013, 328, Figs. 8A–B).

can be destructive (e.g. erosion can be caused by wave action) (Goldberg and Macphail 2006: 114). Flooding of lakeside settlements due to surface flow have caused erosional processes within anthropogenic accumulations (Jacomet et al. 2004) (*Fig. 1.34*).

Micromorphological investigation showed that the uppermost parts of organic cultural layers were more affected by flooding, according to the acrotelm-catotelm model. The loose acrotel of organic accumulations was faster eroded, while the dense, waterlogged "catotelm" was not affected by the flooding and remained in situ; otherwise, a general homogenization of anthropogenic sequences would have been the consequence (Ismail-Meyer et al. 2013: 332). There are several micromorphological features which indicate flooding in the archaeological record, such as reworked layers containing a micrite matrix, or big amounts of well-sorted fine sands, possibly mixed up with organic detritus and micro-charcoal. Archaeological deposits that do not contain any freshwater indicators (such as, for instance, mollusc shells) can be considered as *in situ*, whether they contain fragile components, as wood ashes or well-preserved coprolites (Huber & Ismail-Meyer, 2012). This could be the case of Cham-Eslen (Zug Lake): there sedimentological and micromorphological studies indicated that the single house found was built as a ground-level construction on the top of a small island. Lake flooding led to erosion and reworking of anthropogenic sediments, but in the central part of the building archaeological sediments could be considered as *in situ* (Huber 2009; Huber & Ismail-Meyer 2012; Ismail-Meyer et al. 2013: 332). At the pile-dwelling of Mezzano, lake changes in level and extension occurred in several periods; the positive hydrological balance of the lake was able to flood the nearby flat area, as occurred before and after the Bronze Age. The running water during one or more phases of low lake level produced an erosional surface which was recognised (Sadori et al. 2004: 8–9). Micromorphological analysis performed at Zurich-Alpenquai (Künzler Wagner 2005) showed that inhabitants of this settlement were increasingly and repeatedly forced to face high lake levels between settlement phases: these oscillations must be long enough for considerable amount of lake marl to be deposited between main organic layers. For instance, during phase D characterised by an highly organic layer without any detactable limnic influence, lake levels must have decreased significantly and the uppermost layer reflects a settlement hiatus. Consequently, the settlement experimented at least once a complete inundation (between phases B and C) and an at least partial flooding during phase A (Wiemann & Rentzel 2015: 116–119).

Furthermore, archaeological evidence of lake-level fluctuations within the sites can be find also as spreads of objects which were washed out by the flood itself. For instance, at Siedlung-Forschner on Feder Lake (south Germany) a large quantity of artefacts such as pottery, wooden tools and also animal bones was found out of its original place. They were piled up against the internal side of the village palisade, due to the action of severe flood which moved the objects until they became trapped against the fence (Schlichtherle & Washlster 1986; Menotti 2001b: 100). At Arbon-Bleiche 2, on Lake Constance, a large quantity of wooden planks were discovered in sector L, deposited there by a major flood which occurred at the end of the 16th century BC. Since the level of water in the Early Bronze Age is known (ca 392 m a.s.l) and the village of Arbon-Bleiche 2 was located at about 396 m a.s.l., the lake level had to raise quite considerably in this period. These examples show that lacustrine communities were taking measures to face the natural phenomenon of lake fluctuations. For instance, during the Late Bronze Age, at Ürschhausen-Horn, among others, some architectural attempts to combat rising humidity were realised (Gollnisch-Moos 1999; Jennings 2014: 135). Unfortunately, those solutions have in some cases only been temporary, since the severity of flood could prevail and the exodus from the lakes became, in some cases, inevitable. Thus, the variability of lake level could affect not only the intra-depositional formation of the archaeological deposit but it could be also considered among the reasons that have caused the abandonment of lakeside settlements. Fire events – conflagrations can be listed among intra-depositional processes as well as the likely reasons for the site abandonment, due to their polyvalent nature and their repetitiveness during the past.

4. THE LAKESIDE SETTLEMENT ABANDONMENT: INTRODUCTION

At a certain time-span during the occupation of a village inhabitants decided to abandon the settlement. This is defined as "the process whereby a place, an activity area, structure or entire settlement is transformed to archaeological context"(Schiffer 1987: 89; LaMotta & Schiffer 1999: 22; Cameron 2006: 28). The process of abandonment can occur on a different "level of analysis", concept generally used in social sciences (Babbie 2004; for application of this concept to lake-dwellings see Wiemann & Rentzel 2015: 114–115); it can include a macro-level dimension, that examines the abandonment of lake-dwellings as a general phenomenon and in an inclusive scale, as abandonment of an entire settlement, a potential conglomeration of settlements, or a structure/activity area. It is referred to the settlement and its inherent dynamics; finally the micro-level is focused on houses or house locations (Ebersbach 2010, 2013).

The abandonment has also a temporal component, since it can be a temporary, long term or permanent phenomenon. Each spatial and temporal dimension has different consequences for the formation of the archaeological record. During the abandonment it can be assumed that residents will remove the most useful and portable objects, according to several conditioning factors (Stevenson 1982; Deal 1985; Schiffer 1985; LaMotta & Schiffer 1999; Cameron 2006: 28; Schiffer et al. 2010).

Different modes of abandonment (e.g. see Longacre & Ayres 1968; Lange & Rydberg 1972; Bonnichsen 1973; Robbins 1973; Schiffer 1972, 1976, 1985; Baker 1975; Stevenson 1982; Cameron 1991; Joyce & Johannessen 1993; Kent 1993) could produce peculiar material evidence. During an unplanned and quick abandonment many valuable and usable objects may be left where they were used, forming the *de facto* refuse (Schiffer 1996: 89–97); consequently, they could be removed for use elsewhere according to curate behaviours. These processes are two sides of the same coin, since the former is an accretion process, while the latter a depletion activity (LaMotta & Schiffer 1999: 22). Investigating the chosen mode of abandonment, the complex situation that involves the formation of lakeside settlements has to be highlighted. A chain-like sequence of site construction, abandonment, renovation/reconstruction and further final abandonment characterises these contexts, rather than a simple single linear sequence of events (Jennings 2012: 16). For instance, when a conflagration event has destroyed the settlement, this might be quickly followed by a site rebuilding directly above the previous (e.g. Wasserburg-Buchau, Federsee Lake, Germany (Billamboz 2006) or in the proximity of the original (e.g. the Neolithic settlement of Sutz-Lattrigen-Rütte (Biel Lake, Switzerland) (Hafner & Suter 2004: 23; Jennings 2012: 16). At Lucone di Polpenazze, sounding D, the occurrence of a sudden fire event is testified by the burnt elevated remains of the house and a unique partially burned beam of groundwater ("*trave di falda*") was found; the site was immediately (after one year, dated through dendrochronology) restored through the planting of new posts (Baioni et al. 2007: 89–90), then the material evidence produced during the abandonment has been absorbed simultaneously into the reconstruction layer. On the contrary, when the site would be re-occupied after years, decades or even centuries (such as the abandonment of Early Bronze Age settlements in the northern Alpine region with a subsequent return during the Late Bronze Age, similarly to Ürschhausen-Horn and Oggeslshausen-Bruckgraben, or not re-occupied at all (as Greifensee-Böschen (Eberschweiler et al. 2007), the material consequences of the abandonment could be partially preserved on the archaeological record. However, this evidence could probably be mixed up and even deformed by post-depositional processes. When an increase of water lake level has occurred after the abandonment, the plan has been sealed and preserved in an underwater condition (such as at Arbon Bleiche 3).

The conscious decision of leaving the site, as a temporal strategy or as a definite choice, was triggered by cultural as well as natural factors. In accounting for the entirety of abandonment pictures, a straightforward multi-causal explanation is required, associated with an approach that takes into account the differences involved by peculiar strategies of abandonment in a micro scale as well as in a macro dimension.

4.1 DIFFERENT ABANDONMENT MODES IN THE LAKESIDE SETTLEMENTS CONTEXT

The abandonment of lakeside settlements often conveys images of catastrophe, mass migration and environmental crisis (Menotti 2001b: 145); nonetheless, to correctly explore and interpret the complexity of abandonment processes a focus on the its causes is not exhaustive. An important role is played by the articulation between human behaviour at the time of abandonment and the resulting patterns in the archaeological record. They also hinge upon the different modes and strategies followed by inhabitants during their exodus.

The short-term abandonment seems to be a quite widespread phenomenon in lakeside settlements, probably linked to changing climatic conditions; these variations could force inhabitants to settle shallower areas where they less likely experienced inundation in the event of lake water rise (Menotti 2001b, 2003, 2004; Jennings 2014: 22). Some settlements, for instance Unteruhldingen-Stollenwiesen (Schöbel 1992), Cortaillod-Est/ Cortalloid-Plage/Cortaillod-Les Esserts (Arnold et al. 1986) and Auvernier-Nord (Arnold 1983), were reoccupied but underwent a spatial shift and were gradually moved with each phase of re-occupation and new building activity. The Zurich-Mozartstrasse site shows cultural occupation over 24 centuries between the Neolithic and the Late Bronze Age, with at least 15 phases of occupation and hiatuses (Gross et al. 1987; Conscience 2001; Schmidheiny 2006; Jenning 2014: 22). There, as much as at Arbon-Bleiche 2 and Bodman-Schachen 1, inhabitants experimented slow abandonment processes. In these sites, directly affected by increasing water levels, inhabitants had enough time to plan the exodus, as demonstrated by the artefact distribution, as well as the conditions of the found houses. Although the word "abandonment" may cover a message of sudden catastrophic events, the Middle Bronze Age exodus from lakes in the northern part of the Alps was a considerably long process which lasted more than half a century. Lake waters were rising steadily but people had enough time to plan the abandonment and look for new land to settle again. A paramount aspect that former lake-dwellers had to take into consideration was the safety of the new environment, which had to be located far enough from the lakeshores so that is would not have been influenced by the lake transgressions in the years to come (Gross et al. 1987; Hochuli 1994; Menotti 2001b: 163).

The abandonment of a settlement can be related to a series of processes, which included two micromorphologically recognisable ones, according to Wiemann & Rentzel 2015: these are "events of fire and lake-level increases after the abandonment, as well as the associated erosion and subsequent lake marl coverage" (Wiemann & Rentzel 2015: 119). At Zurich-Alpenquai the abandonment of the settlement within phase B seems to be related to a fire event, taking into account that the layers of this phase were characterised by high loam content, only a small amount of organic material and the consideration that some of the loam bore revealed traces of burning (Künzler Wagner 2005; Wiemann & Rentzel 2015: 119). In some cases the effect of erosion can erase clear evidence of the final phase of site and its abandonment on the archaeological record, as observed within the most recent phase at Zurich-Alpenquai and also at Greifensee-Böschen, as stressed by Wiemann & Rentzel (Wiemann & Rentzel 2015: 114–119).

Five distinct phases of settlement and occupation are attested at the site of Zurich-Kleiner Hafner that covers a period from the 4th to 2nd millennium BC (Suter et al. 1987; Jennings 2014: 22). Shorter cycles of abandonment and re-occupation also occurred, such as at Bodman-Schachen 1 (Constance Lake) (Köninger 2006) and at Dispilio (Orestias Lake) (Karkanas et al. 2011). At the lake-settlement of Zug-Sumpf (Switzerland) an abandonment of the site four years later to a flooding event that took place around 944 BC was followed by a further phase of occupation occurred between 880 and 860 BC (Bauer et al. 2004; Jennings 2012). At Lazise-La Quercia different site occupation phases (layers II, IV and VI) have been divided by clay levels characterizing abandonment, identified within the stratigraphy (Fozzati et al. 2015: 247).

At the site of Peschiera del Garda-Frassino, the first pile-dwelling is separated from the above "dry" settlement by an horizon of peat and lacustrine deposit, that testified the occurrence of a water level change. The abandonment of the underlying pile-dwelling is defined by an increase – and a consequent decrease – of the lake water level that caused the formation of a peri-lacustrine peat bog, probably occurred during the early phases of the Middle Bronze Age (according to dendrochronological dates) (Martinelli & Kromer 1999), before the installation of the new "dry" settlement (Fozzati et al. 2015: 245–7).

Few lake-dwellings show only a single short occupation, as Arbon-Bleiche 3 (Jacomet et al. 2004; Leunzinger 2001) and Greifensee-Böschen (Jennings 2014) or sites where the Late Bronze Age abandonment have a permanent nature, as they were never resettled. The decision whether or not to reoccupy former lakeside sites can be related to specific causes and involve, as well as trigger, specific explanations. The visual presence of former dwellings on the lake-scape (Jennings 2014: 34) plays a significant role: the material evidence of pile-dwelling structures (timber, piles, palisade) must have been visible in the period following the abandonment. These remains and even the social memory of successfully inhabiting that area (Arnoldussen 2013) could push communities to return after a gap, as at some Late Bronze Age sites (Ürschhausen-Horn, at Nussbaum Lake, Switzerland, Wasserburg-Buchau, at Feder Lake, Germany, Hauterive-Champréveyres, at Neuchâtel Lake, Switzerland, Zurich-Alpenquai, at Zurich Lake, Switzerland, and Zug Sumpf, at Zug Lake, Switzerland). There, although it is unknown whether same communities were returning to their previous sites, the material culture from the region indicates local development rather than incoming populations to the area (Jennings 2012: 13). Nevertheless, some factors could act to prevent the re-occupation of a lake-dwelling. Negative properties, values and associations of places (Chapman 1998: 112; Jennings 2014: 36) can go in this direction, together with the indirect memories, that can be related to similar places and times (Bender 2002: 107; Jennings 2014: 36).

The Middle Bronze Age lake-dwelling hiatus may be interpreted in this perspective: when more favourable climatic conditions and more stable lake levels returned, social memories of settlements and the visual recognition of former pile-dwelling structures (Menotti 2001a–b) allowed communities to come back to the lakeshore. The decision whether to resettle a site has been linked also to the will of reproducing or on the contrary changing cultural values and meaning, through the use of historical, traditional and ancestral places (Chapman 1998: 110). According to this perspective, the continued use and re-occupation of lake-dwellings may have been an attempt to maintain the social *status quo*; this condition may enable to retain links to ancestral practices, beliefs and values, creating and continuing a sense of community identity (Jennings 2014: 36).

The cyclic abandonment and re-occupation of lake-dwellings suggests that they were constructed with temporal considerations in mind (Gerritsen 2008: 151); they were built with an intended life-span or temporal duration that may have been dictated by the durability of construction materials used, by agricultural concerns or related to the life cycle of the community, before they were abandoned. The occurrence of "old" objects may be interpreted according to a perspective of continuity. For instance, Early Bronze Age needles in Late Bronze Age contexts in wetland assemblages also raise the possibility that items were curated over extended periods as cultural heirlooms (Fischer 2011: 1301–02). However, such items could be encountered also during Late Bronze Age activities – as agricultural processes – and then retained as curiosities (Hingley 2009). In any case, if they were retained as heirlooms, such objects may have been used as indicators of legitimacy to reside in certain locations. Instead, if they were encountered in the local environment they may have provided indications to settle specific sites. As highlighted by Jennings (Jennings 2014: 118) further interpretation can be garnered from the condition in which objects were deposited. The single objects as well as material evidence of previous occupation may be reused: if they were still visible part of old houses, the may have been dismantled and the wood reused to build new dwellings situated near the abandoned site (Menotti 2001b: 146). The use of halved or quartered timber for piles and the utilisation of recycled timber is attested at few Late Bronze Age settlements, as Hauterive-Champréveyres (Neuchâtel Lake, Switzerland) (Pillonel 2007), Conjux Le Port 3 (Bourget Lake, France) (Billaud 2008) and in oak piles at Zug-Sumpf (Seifert 1996: 64–73) (Jennings 2012: 12); the piles were removed at the sites of ZH-Mozartstrasse, Arbon-Bleiche 2 and Bodman-Schachen 1, except those driven in the ground (Menotti 2001b: 146). When remains of previous settlements are still available but the distance from the new site is quite substantial, it is not worth it to shift the construction material for long distances; then, settlements are destroyed by setting them on fire (Menotti 2001b: 146). This practice seems to be quite widespread, although, in the majority of cases, the data do not enable to recognise their deliberate or unplanned nature, as in some Italian pile-dwellings and lakeside settlements (such as Fiavé, Ledro, Lavagnone, Lagazzi, Canar, Feniletto, Isolino di Varese and Ciseno). Since in some circumstances single structures appear to have been destroyed by fire at different times, it is possible that they were not accidental conflagrations but the deliberate and selective destruction of individual buildings. Instead of buildings simply being left to decay rapidly after the abandonment (Schöbel 2011), micromorphological analysis have proved that burning events may have been the last action. At Ürschhausen-Horn, individual buildings were destroyed without fire spreading to adjacent, despite the close proximity to structures. This deliberate destruction of dwellings and households (Bönisch 2005) as opposed to accidents or "catastrophes" afflicting the village (Leuzinger 2000: 165) may have marked the end of a life or household stage. Otherwise, it could simply provide an easy method to clear a site in advance of fresh construction, or to ensure that incoming groups could not utilise previous household structures (Jennings 2014: 17). In the archaeological contexts that showed clearly signs of deliberate destruction by fire, a planned abandonment of temporary or indefinite nature can be imagined as the most likely scenario. Further evidences provided for Ürschhausen-Horn can confirm this reconstruction. The typology, dating spread and quantity of artefacts recovered from specific areas have been used as an argument against the sudden abandonment of lake-settlement (Müller 1993: 86). For instance, at Ürschhausen-Horn exceptionally little and few pieces of metalwork were found at the site, suggesting that some of the building were cleared before their deliberate abandonment (Nagy 1999); this process finds support in ethnographic survey (e.g. Deal 1985; Jennings 2014: 118).

Furthermore, the distribution of pottery at the settlement indicates that ceramics were placed along the outside of the buildings and fragments of individual vessels were dispersed amongst several structures (Gollnisch-Moos 1999; Nagy 1999). Even in this case ethnographic studies (e.g. Hayden & Cannon 1983; Deal 1985) have demonstrated that ceramics may be temporarily stored along the outside of buildings, following breakage and during the abandonment such vessels are left in situ, as de facto/abandonment refuse, while intact and usable vessels are removed. All these data may suggest planned abandonment and destruction of buildings rather than accidental fire or hurried evacuation (Jennings 2014: 118). An inverse circumstance seems to characterise the abandonment of the Viverone pile-dwelling (VI1-Emissario). In this Middle-Late Bronze Age site apparently associated metalwork consisting of an entire female "parure" and weapons were found; scholars consequently suggested an hypothetical sudden abandonment of the site or an

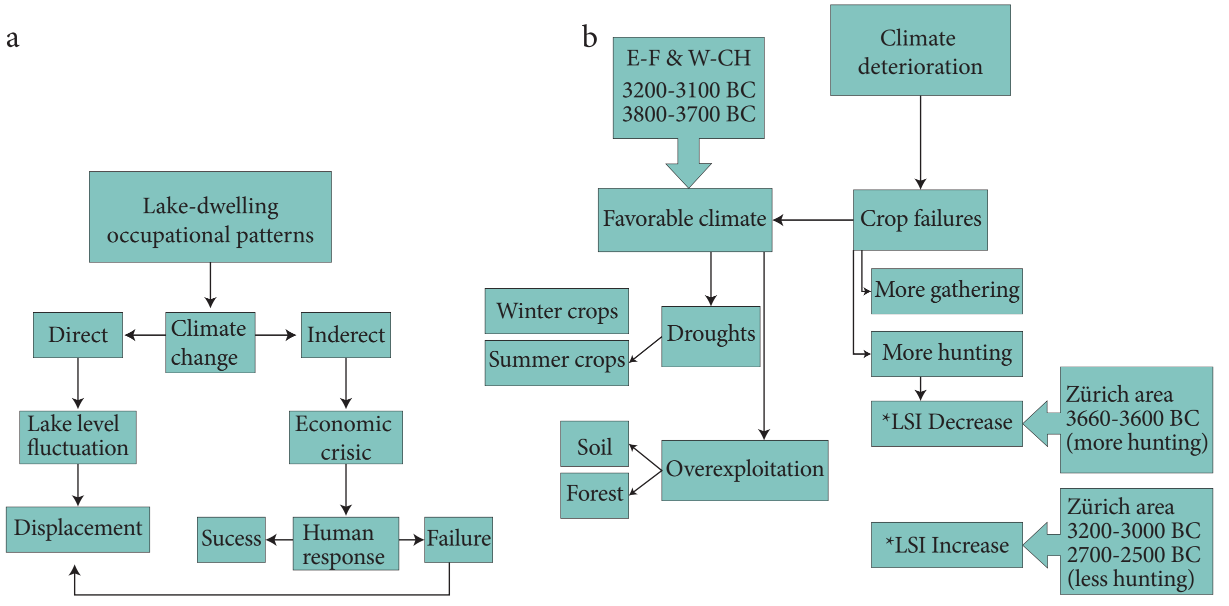


Fig. 1.35: a) Direct and indirect influence of climate change on lake-dwelling occupational patterns (from Menotti 2009, 63, Fig. 2); b) negative effects of both favourable and unfavourable climatic conditions on crop cultivation in the northern Circum-Alpine region lake-dwelling tradition (from Menotti 2009, 64, Fig. 3).

impossibility to recollect these artefacts (Menotti et al. 2012: 197). At Castellaro Lagusello (Piccoli 1982: 448) the occurrence of some prestigious elements (such as amber and bronze artefacts) as much as some antler and lithic artefacts have suggested an hypothetical sudden abandonment. Nevertheless, in interpreting our archaeological record, a potential further use of water, highlighted by Menotti (Menotti 2001b: 146) have to take into account. Water courses and water basins, if not used as sources of drinkable water, have always been used as natural dumps. Therefore, also the lake-dwellers discarded large quantities of pottery fragments, animal bones and other objects in the nearby lake, which in some cases was part of the settlement. As a result, the distribution of those objects can be misleading during archaeological analyses.

4.2 THE CAUSES OF ABANDONMENT IN THE LAKESIDE SETTLEMENTS CONTEXT

Among the many combined factors that influence past social dynamics, climatic change directly or indirectly played a role in the abandonment of lake-dwellings (Magny 1992b, 1993, 1995, 2004a, 2004b; Menotti 2001a–b, 2003, 2004; Magny et al. 2009; Menotti 2009; Menotti & O'Sullivan 2012; Jennings 2014) (*Fig. 1.35*).

For instance, the direct effect of climatic deterioration led to the increase of lake water level and consequently the inundation of the surrounding wetland settlements. Because of the flat land morphology, flooding reached also the lake hinterland, as it has clearly been shown by GIS computer simulations of

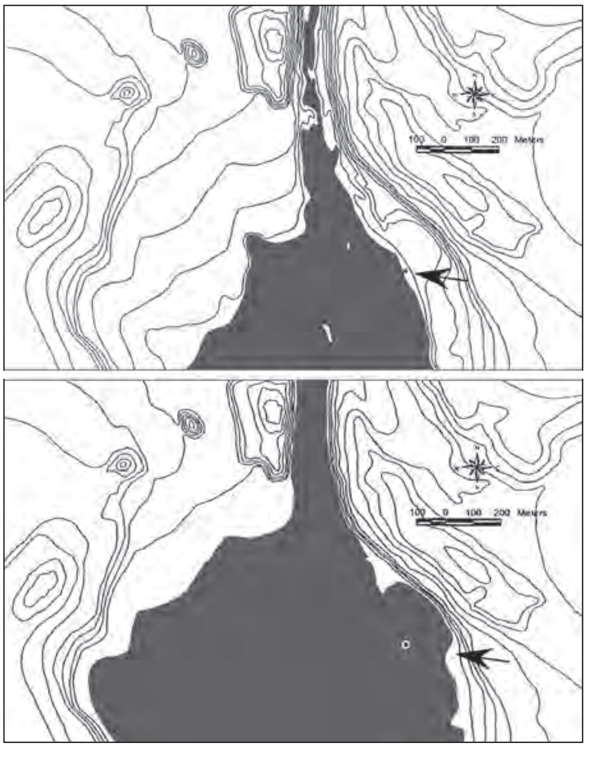


Fig. 1.36: GIS computer generated simulation of the Zurich Lake level as it might have been in the Early and Middle Bronze Age (from Menotti 1999, 149–52, Figs. 3 and 4).

lake transgressions in the Zurich bay, Arbon bay and Bodman bay at the end of the Early Bronze Age (sites of ZH-Mozartstrasse, Arbon Bleiche 2 and Bodman-Schachen 1; Menotti 1999; Menotti 2001b) (*Fig. 1.36* shows the example of Zurich Lake). Despite this alterations of lakes, hydrological balance used to occur regularly in seasonal term with controlled consequences. When it assumed more drastic long-term character, a forced alternative strategy was required. Since tillable lands in site's surroundings were almost entirely used for agriculture and animal husbandry, their flooding forced lake-dwellers not only to shift their habitations but also to face with economic crises related to food production and subsistence (Schibler & Studer 1998; Menotti 2001a; Menotti 2003; Menotti 2009; Menotti 2012; Jennings 2012, 2014). Furthermore, cooler/wetter conditions meant that sufficient crops could not be produced for the comparatively large and high population density settlements when contemporary inland sites are considered (Arbogast et al. 2006).

Then, a loss of economic sustainability can be included into the indirect influences of climatic changes (Jennings 2014: 20): the solution was mainly based on mobility and diversification practices. Nevertheless, these combined direct and indirect effects may not have been significant enough to cause the abandonment of the lake-dwelling tradition across the entire Circum-Alpine region, particularly given the varying sensitivity of lake level changes across the region (cf. Bleicher 2013). Some cultural influences featured in the widespread phenomenon of lakeside settlements' abandonment: according to the scenario proposed by Menotti for the Middle Bronze Age hiatus (Menotti 2001b), this was not simply a "settlement reaction" to altered conditions, but a cognitive response to changed circumstances. An initial environmentally triggered crisis became a larger-scale cultural phenomenon, through local and interregional exchange networks (Jennings 2014:20), as it came to include sites which would not have been directly affected by rising lake levels (Menotti 2001b: 141).

As within the lacustrine communities of the northern Alpine region towards the Early Bronze Age (16th century BC), effects of the economic crisis experienced by an influential cultural group within a regional context are bound to be transmitted on to other communities through commercial activities which link more groups together (Menotti 2001b: 145–146).

The decision to desert lakeshores, which had initially been triggered by environmental factors, became cultural and the influence on lacustrine occupational patterns began to cover much larger areas, transforming the exodus into a global regional phenomenon. The majority of the Early Bronze Age lacustrine sites in the northern Alpine region were abandoned within the 16th century BC and in particular towards the end of it. As highlighted by Jennings (2014: 20), the influence of "negative" attitudes and perceptions of an area due to climatic and environmental change have recently been illustrated by Leary (2009) linked to the early 20th century abandonment of Holland Island (Chesapeake Bay, Maryland, USA): the sea level rise created negative attitudes towards the future of the island, despite the fact that it remained habitable for a significantly longer time span (Arenstam Gibbons & Nicholls 2006).

Furthermore, lakeshore abandonment might have been also caused by demographic expansion linked to migrations and environment overexploitation. A good example is the Neolithic lake-dwellings at Chalain (France); possibly due to the influx of external cultural groups (the Eastern-Swiss Horgen groups, South-west Ferrieres groups and northwestern groups from the Saone Plain), a demographic increment between 3200 and 3000 BC was experienced (Arbogast et al. 1995; Pétrequin et al. 2005).

A series of effects, such as an increase in hunting activity (due to a higher demand for meat), overexploitation of cultivable land and the felling of primary forest trees for building houses were triggered. A combination of all these factors was probably what forced lake-dwellers to move to other areas, as the region of Clairvaux Lake, in search for more abundant natural resources (Arbogast et al. 2006).

The history of prehistoric settlements in wet areas as those recognised at north of the Alps strongly contrasts with that reconstructed south of the Alps. In northern Italy, archaeologists observed that a relative continuity of lake-dwellings was maintained all through the Bronze Age; furthermore, the Middle Bronze Age seemed to mark a maximal development of lake-shore and wetland pile-dwelling villages (Perini 1994; Guidi & Bellintani 1996; Martinelli 2005; Magny & Peyron 2008; Magny et al. 2009: 576) (*Fig. 1.37*). The regional peculiarity of northern Italy is still confirmed by Terramare which developed in humid areas of Po plain during the Middle and Recent Bronze Age (Cremaschi et al. 2006). Unfortunately, paleohydrological records established from high-resolution studies of lacustrine sediment sequences and based on robust chronological data are still rare in northern Italy, to test whether differences observed between the history of Bronze age lake-dwellings north and south of the Alps were linked to different regional paleohydrological patterns or to a different socio-economic organisation of societies. Nevertheless, through the pile-dwellings' available dataset, such as those of Ledro (Magny et al. 2009), for the Northern Italy, and some from Central Italy, such as, among others, Mezzano Lake (Giraudi 2004; Sadori et al. 2004), Fucino Lake (Giraudi 1998) and Accesa Lake (Magny et al. 2007), scholars were able to draw some preliminary conclusions. According to Magny (Magny et al. 2009: 585–6; Magny 2013: 585–98), despite a climate characterised by increasing

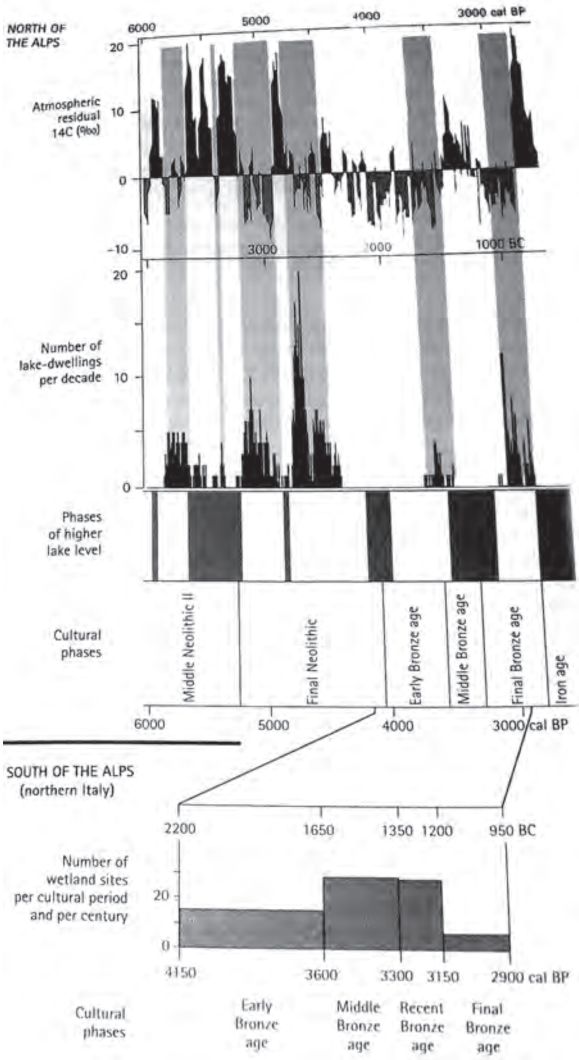


Fig. 1.37: Frequency of lake-dwelling per cultural phases north and south of the Alps. Upper panel: Neolithic and Bronze Age lake-dwellings in eastern France and on the Swiss Plateau. Lower panel: frequency of Bronze Age lake-dwellings in northern Italy as estimated from archaeological remains found in wetland areas (from Magny 2013, 593, Fig. 34.4).

moisture between 1500 and 1200 BC, Bronze Age settlements south of the Alps remained in humid areas of lakeshores and in the Po plain. On the contrary, the following drier climatic conditions appeared to be synchronous with a general crisis of lake and wetland villages and also coincided with an abrupt end of Terramare. As a working hypothesis, scholars suggested a peculiar socio-economic organisation of Bronze Age societies in northern Italy (Magny et al. 2009; Magny 2013: 594) (*Fig. 1.37*).

For instance, the end of Terramara culture appeared to be quite sudden everywhere in the Po plain; climatic changes cannot be regarded as the only force that determined their sudden decline (Cremaschi 1997; Bernabò Brea et al. 1997; Cardarelli 2010). The relative degree of human influence and climatic factors largely differs on a regional scale, but on the Po Plain both Holocene climatic changes and anthropogenic activities produced distinctive geomorphological effects. Here much of the land was deprived of its original vegetation by fluvial modifications such as flooding and through human activities as forest clearance and ploughing, this producing intense aerial erosion (Marchetti 2002). Probably a coincidence of many factors (Bernabò Brea et al. 1997) with the synchronous occurrence of climate deterioration and overexploitation, as suggested by the archaeobotanical record of Montale, took place in the area. In fact, in this site signs of crisis have appeared archaeologically around 1300 BC when even the number of settlements in the area diminished, while remaining sites did not enlarge their boundaries (Cardarelli 1997). These data was compliant with the pollen diagram that, for this time-span, detected the fall in forest, less pastures and an increase in open areas with a more stable record of weeds (e.g. *Centaurea nigra* type, *Cirsium, Polygonum aviculare* type, *Platago lanceolata* type), probably occupying abandoned fields. Such a crisis was possibly due to overexploitation of woods and soils (Mercuri et al. 2006: 57). The environment was less suitable for cultivation than before and the wood was not able to recover quickly. Nevertheless, in marine and lake cores signs of deforestation continued and led to maxima at around 1100 BC (Mercuri et al. 2002; Oldfield et al. 2003). In agreement, archaeological data show that the Terramara di Montale was abandoned at ca. 1200 BC, when this culture ceased quite suddenly everywhere in the Po plain.

This climatic event causing dry conditions may also have contributed to the final abandonment of the Poviglio Santa Rosa Terramara (Reggio Emilia-Italy); the clear drop in the water levels during the late Recent Bronze age, corresponding to the final phase of the site occupation, involved the collapse of the hydraulic system discovered, in general, in Terramare culture and in particular at Santa Rosa. The moats surrounding most of sites were probably conceived to concentrate water and redistribute it to the surrounding country through a network of irrigation ditches (Cremaschi et al. 2006: 95). At Santa Rosa a system based on large water wells and interconnecting ditches was found; scholars stated that in this recorded hydrological crisis, the aridity was a limiting factor affecting land use at the final stage of the settlement (Mercuri et al. 2014: 232), as it was the local expression of a regional dry event. The further pollen data from Terramara of Baggiovara (Cardarelli 2009; Mercuri et al. 2015) suggested that the site was always less forested and therefore less suitable for wood exploitation. The greater space for houses is confirmed by archaeological data on demography which states that such pressure was higher in this area than elsewhere. However, this is possibly among the causes of short existence of Baggiovara. Cardarelli (2009: 48) concluded that the Terramara di Baggiovara and Tabina di Magreta, among others, were abandoned when a major re-organisation of the territory occurred in the Middle Bronze Age. The land transformation occurred at that time became a cause of crisis for Baggiovara. There, a limiting factor seems to have been the wood loss rather the a water shortage, that took place in later phases (Mercuri et al. 2015: 247). Also in the Emilia region, in the Terramara of Gaggio di Castelfranco Emilia (Modena) the phase of site abandonment is marked by the agricultural exploitation of the intra-site space, between the end of the Middle Bronze Age and the beginning of the Late Bronze Age (Balista et al. 2008; Nicosia et al. 2011: 290).

Although is confirmed the role played by climatic component in the disappearance of Terramare, a multi-causal explanation is required, as suggested by scholars, that considered the end of the Terramare culture as a consequence of a societal collapse (de Marinis 1975; Barfield 1994; Balista & De Guio 1997; Bernabò Brea & Cardarelli 1997; Bernabò Brea et al. 1997; Cardarelli 1997; Pearce 1998; Cremaschi et al. 2006; Cardarelli 2010; Cremaschi 2010; Frontini 2011). This cannot be interpreted as the result of a simple relationship between demography, climatic crisis and environmental decline; then, justifying the radical change that took place in the Po Plain during the first half of the 12th century BC, social and political explanations are required. This need did not hinder an environmental factor but may well have been triggered or enhanced by it (Bernabò Brea et al. 1997; Cremaschi 2010). In a social and political system which took place within a tribal order[3], the demographic growth as well as the diminution in land yield and increasing drought did not allowed Terramare to withstand, being impotent to change their economic and social model, as well as their system of production. In this condition it was probably necessary to put an end to the harmonious social development that had been a feature of Terramare for centuries. It is legitimate to suppose that in some areas of territory occupied by Terramare the transition away from the ancient tribal order may have been set in motion (Cupitò & Leonardi 2005; Leonardi 2010; Cardarelli 2006) but it appears generally evident that Terramare remained on the whole a society characterised by a strong sense of tribe and community. Social impracticability of a transition to a new system of production and a new political order seems to have been the principal reason for Terramare's inability to respond to the crisis and hence also the cause of their definitive collapse (Cardarelli 2010: 484). Nevertheless, the end of this culture did not seem to have left widespread signs of violent destruction, neither are there accumulated traces of natural events, as happens when flooding leaves deposits. Archaeologists are not able to establish whether the abandonment was simultaneous across the entire territory or it was a result of several years or decades of crisis. However, this last hypothesis seems more likely, as archaeological evidence shows that various Terramare completed their life cycle before the end of the Recent Bronze Age (RB2) (Cardarelli 2009; Cardarelli 2010: 485). The *diaspora* of Terramare's inhabitants would be the result of a gradual abandonment of villagers divided in limited groups, over decades, following a known process of penetration/colonisation (Yasur-Landau 2007). As suggested by Bietti Sestieri (Bietti Sestieri 2005) and supported by Cardarelli (2010: 486) the depopulation of the Terramare could have occurred with the relocation of small groups, ascribing to this dynamic the transfer to neighbouring regions of techniques and know-hows pertaining to Terramare area.

As in the case of Terramare, the Middle Bronze Age lakeside settlement hiatus was characterised by considerable social changes related to economic crisis those communities were experiencing. Three main Early Bronze Age lacustrine sites (ZH-Mozartstrasse, Arbon-Bleiche 2 and Bodman-Schachen 1) probably played a central role even influencing other lacustrine communities. Due to economic instability, these dwellers decided that lakeshores were no longer safe enough to settle: since they were not committed to vast agricultural production, trade networks and intra-village complex social structures, although they were not threatened by flooding waters, they left lakeshores even earlier than the three main sites mentioned above. The abandonment of the northern Alpine foreland lakeshores (the so-called Middle Bronze Age lake-dwellers' exodus) coincided with the expansion of the Tumulus culture, towards the northern Alpine region fringes. This culture covered a fairly vast territory namely Bavaria, northwestern Austria, the Baden-Württemberg region between the Rhine and the Danube and a few sporadic areas around Constance Lake and Zurich Lake (Menotti 2001b: 146–7). An interesting aspect of the Tumulus culture is that it has never been found on lakeshores. Two plausible hypotheses regarding this culture are formalised: since the time of its expansion was the same as when lakes started to be deserted, probably the hostile flooded lakeshores did not attract those groups; on the other hand, the Tumulus culture in the Alpine foreland could have developed from a process of acculturation between the Early Bronze Age lake-dwellers and the Early Bronze Age terrestrial groups. Indeed, while the former were abandoning their lacustrine settlements, the latter were absorbing them (Köninger 1996; Menotti 2001b:147). However, it is sure that the abandonment

[3] For the use of word tribal see Cardarelli 1997, 2006, 2009. In the broader sense, the meaning of tribal is substantially equivalent to that of a community with a territorial base or functional and territorial as proposed in Peroni 1996, 1999, 2004 (Cardarelli 2010: 471).

of the northern Alpine lakeshores towards the end of the Early Bronze Age and the beginning of the Middle Bronze Age generated an increment of cultural mobility throughout the entire Alpine region.

The climatic interpretation has been favoured even exploring the cause of Middle Bronze Age hiatus settlements (Magny 1995; Menotti 2001b; Van Geel & Magny 2002; Magny et al. 2009). The final abandonment of the lake-dwellings, occurred in 800–600 BC ca. in the northern Circum-Alpine region and in 1200 BC ca. in northern Italy (de Marinis 2009) has instead been interpreted as strongly driven by cultural factors (Jennings 2014: 23). Although the beginning of the Iron Age was marked by a slight climatic deterioration, several phases of favourable lake water levels have followed (e.g. Härke 1979: 32, 65; Pétrequin & Bailly 2004: 40–44). Furthermore, although the time interval when lake-dwellings were being abandoned across the northern Alpine region appears to correspond to a prolonged period of higher lake levels, the gradual decline in the occupation of such sites began during the period of lower levels up until 800 BC (Bleicher 2013). The transition from the Bronze Age to Iron Age in Europe is a complex time period which can in many respects be seen as the expansion of cultural systems and processes that existed during the Late Bronze Age (Thurston 2009: 351). During this chronological phase cultures of the Circum-Alpine region started to gradually reject a tradition of lake-dwelling occupation in favour of open and upland settlements, fortified hilltop sites (Härke 1979, 1989; Benkert et al. 1998; Jennings 2014: 23). The last lake-dwelling in the Alpine region to be abandoned was Ürschhausen-Horn, during the 630 BC (Billamboz & Gollnisch 1998; Gollnisch-Moos 1999). Unlike the Middle Bronze Age hiatus, the Late Bronze Age – Early Iron Age abandonment process occurred over an extended period of time, with lake-dwelling gradually being abandoned and not reoccupied. In the northern Circum-Alpine region this phase has begun immediately following the Middle Bronze Age hiatus, since many lake-dwelling sites were never re-occupied and the number of lake-dwellings known within the Circum-Alpine region is significantly reduced after this hiatus (Magny 2004b; Magny & Peyron 2008) (*Fig. 1.33*).

Furthermore, several Late Bronze Age settlements show no indication of previous site occupation, such as Greifensee-Böschen and Konstanz-Raue, while few others, such as Steckborn and Kreuzlingen on the Constance and Mörigen Lakes, showed re-occupation from the Neolithic and Early Bronze Age (Jennings 2014: 23). Although the lake-level transgression did not appear as unique cause of the lakeside settlement abandonment, the climate component may have played an important role, as at the Zurich-Alpenquai site. The partial absence of the crucial last occupational layer, associated with a reliable dendrochronological date from a house component (844 BC), led scholars to wonder as to whether there is more to it than met their eyes. However, the current state of the art does not enable to explain why the settlement was left for good (Wiemann et al. 2012: 82).

The inland movement from lakes was, as already mentioned, not limited to the northern Alpine region: although it happened about a century later, also in the southern parts of the Alps the quest for drier land to settle occurred and the cognitive response to adaptive processes was quite similar to that of the northern lacustrine communities. For instance, at the site of Fiavé in the pre-Alpine region of north-eastern Italy, the houses of the last horizon, namely Fiavé 7, assumed particular Late Middle Bronze Age- Late Bronze Age characteristics of construction which resembled those of land settlements. All dwellings belonging to Fiavé 7 were built on the dry ground of both the island of zone 1 and on the hilly area of "Dos Giustinaci", situated 200 metres south of zone 1 and 2. All houses of Fiavé 7 have large planimetry and stone floors are made of gravel and pebbles, very similar to the typical Middle Bronze Age land settlements; dwellers of Fiavè 7 chose to construct their houses according to this model, ignoring examples constructed by their ancestors in front of their eyes (Menotti 2001b: 148). As the foundation of a "new" settlement, may modification of construction models have symbolised the succession of elites before the intention to relocate was marked? Alternatively, the timing of settlement abandonment and relocation or renovation may have been influenced by the age of inhabitants, agricultural productivity, community beliefs, unusual events or the structural condition of buildings (Ebersbach 2010: 152).

Furthermore, asynchronous abandonment of dwellings within an individual settlement and the suggestion of immediate reconstruction after abandonment/destruction are indications that a climatically centred model for the abandonment of lake-settlements does not elucidate the full situation. In some cases, although superficially the example would appear to corroborate the climatically driven abandonment hypothesis, a deeper analysis proves this assumption as simplistic. For instance, at the lake-settlement Zug-Sumpf a flooding event had occurred around 944 BC but the abandonment of the settlement was delayed by four years, with a temporary character, since a further phase of occupation occurred on the site between 880 and 860 BC (Bauer et al. 2004). A further example of continued occupation, despite an increasingly humid or inundated environment, can be seen in the LBA settlement of Ürschhausen-Horn (Switzerland). At this settlement, occupied between 870 and 800 BC, building techniques have changed over time in order to compensate for increasing ground humidity (Gollnisch-Moos 1999; Nagy 1999). These two examples provide clear indications that Late Bronze Age lake-settlements were not always abandoned due to the threat of rising lake-water and the inhabitants of some settlements took measures to counteract increasing humidity and continued occupation despite inundation.

However, the flooded area could have influenced the economy of the community, which in turn may have led to settlement displacement (Menotti 2003). Despite the preservation of structural elements and the potential for highly accurate dating of those elements, other than establishing settlement occupation phases and construction sequences, relatively little theorisation of lake-dwelling biography or development has occurred (Jennings 2014: 5).

5. POST-DEPOSITIONAL PROCESSES IN THE LAKESIDE SETTLEMENTS CONTEXT

The significant difference between wetland and dryland contexts in preserving organic material is pointed out in almost every wetland archaeological publication; the particular advantage of the pile-dwelling or lakeside- lakeshore settlements is the preservation of finds to a degree that is rarely found elsewhere. However, it is clearly understood that the level of preservation varies considerably from place to place even within waterlogged conditions; different wetland ecosystems have different preservation properties, which go beyond sheer water-saturation. Soil chemical composition, pH, and redox potential play a crucial role in the survival of artefacts after deposition (Menotti 2012: 226). Furthermore, a myriad of tightly interwoven cultural and environmental factors can alter this "equilibrium" (Menotti 2012: 203; Menotti & O'Sullivan 2013: 417). In most lakeside sites it is not easy to determine the extent of distortion provoked by natural processes in the anthropogenic signal. In such settlements, pile-dwellings are often constructed on raised platforms and the underlying deposits are therefore not directly related to the actual anthropogenic activities. Cultural materials falling in the water are moved, sorted and graded by wave action and redistributed by erosion during lowering of the lake level and bioturbation in the littoral zone (Karkanas et al. 2011: 84). Human activities, as the modern exploitation of lakes and their surroundings, can also alter our archaeological record. After the settlement abandonment, however, natural environment that preceded may sometimes be restored, granting a good preservation of the archaeological record. For instance, at Stagno, the restoration of lagoonal environment is testified by the nature of sediments which sealed the archaeological deposit. This condition ensured the conservation of wooden structures, found in the grey organic clay banks at about 3.5 m below the soil level, whose spread reached an extension of about 4500 m^2 (Giachi et al. 2010: 1260–1, 1267). Furthermore, the absence of strong post-depositional deformations can avoid the re-arrangement of objects that remain in their original place in the strict sense of the term: examples of this phenomenon are the hearths in the Neolithic sites of Ehrenstein (Zürn 1965) and Taubried (Strobel 2000) or the wooden installations of Seekirch-Stockwiesen (Schlichtherle 2004) and Greifensee-Böschen (Eberschweiler et al. 2007), as suggested by Bleicher (Bleicher 2013: 52). At Arbon-Bleiche 3, the fact that the site was occupied only once, sealed by lake marl deposits soon after its abandonment and even not disturbed by human or natural influences until it was excavated in 1993, enabled the accurate reconstruction of some steps of its formation, revealed by a detailed micromorphological analysis. It was also possible to determine that the thin stratum above the lake marl, accumulated straight after the village was abandoned, was not a subsequent occupation but a layer of reworked debris from the same village, deposited by wave action much later (Ismail-Meyer & Rentzel 2004; Ismail-Meyer 2010; Menotti 2012: 272). Therefore, a full understanding of stratigraphic deposits from a geoarchaeological perspective is crucial in order to reconstruct why our archaeological record is as it is now. This goal will be reached through the analysis of each stage of the deposit deformation.

5.1 NATURAL POST-DEPOSITIONAL PROCESSES

After the deposition stage, a variety of changes can occur within an archaeological sediment. They can affect artefacts on a micro scale, the settlement in a semi-micro scale and, finally, the regional perspective in a macro scale. Natural phenomena such as lake level transgressions and flooding, regardless of reasons that provoked them, perturb in different ways the archaeological record. The unstable nature of such changes can involve consequent lake level drops which favour erosion and the compression of archaeological layers. Furthermore, these transgressions involve wave action and water currents that can rearrange the artefacts' spatial distribution. Conversely, if the flooding becomes more stable, it can partially favour the preservation of the archaeological record. In a micro scale, wetland environments (e.g. peat, fen, mire etc.) can facilitate some post-depositional processes as trampling and decaying processes, which affect in particular the micro and semi-micro scale of analysis.

5.1.1 NATURAL POST-DEPOSITIONAL PROCESSES ON AN ARTEFACT SCALE

Traces of occupation or trampling are phenomena well known from studies carried out on terrestrial settlements (Courty et al. 1989) and have also been experimentally recreated (for instance, Rentzel & Narten 2000). Trampling assumes a central role among the most invasive process that can affect the artefact, particularly within the cultural horizons; its effects may appear from the first moment of the site's occupation. When human activities started on platforms, trampling led to a slight compaction of the surface. Wood chips from wood working, loam aggregates for floor and wall structures were accumulated (Pétrequin 1997; Leuzinger 2007); instead, remains of food preparation were trodden into the ground surface (Ismail-Meyer & Rentzel 2004; Ismail-Meyer et al. 2013: 325–326), trampled by cattle and finally scavenged by dogs in rubbish heaps for bones (Bleicher 2013: 52). Since these are processes that reflect living conditions in the settlement, Bleicher proposed to consider them as an integral part of the archaeological record, rather than as a bias (Bleicher 2013: 52). Trampling is usually limited to minerogeneous sediments that retain better the change of microstructure (Courty et al. 1994; Matthews 1995; Rentzel & Narten 2000; Ismail-Mayer et al. 2013: 333). Within shore platform sediments, as quoted by Wallace (1999), archaeological traces of trampling in lakeside settlements are limited to installation horizons, loam layers (including clay), sandy in-wash layers and only slightly organic cultural layers, such as at Arbon-Bleiche 3, Lobsigensee and Cham-Eslen (Huber & Ismail-Meyer 2012; Ismail-Meyer et al. 2013: 327; 333) (*Figs. 1.38* and *1.39*).

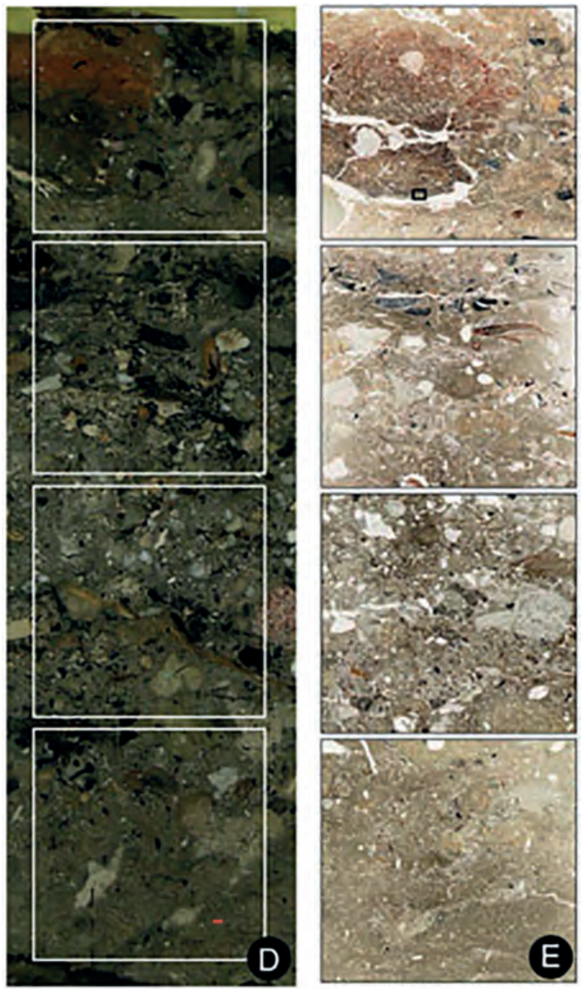


Fig. 1.39: D) Polished section with the position of the thin sections marked in white; E) scanned thin sections and description of the micromorphological phases and their possible reconstruction, Cham-Eslen (from Ismail-Mayer, Rentzel, Wiemann 2013, 322, Figs. 3D–E).

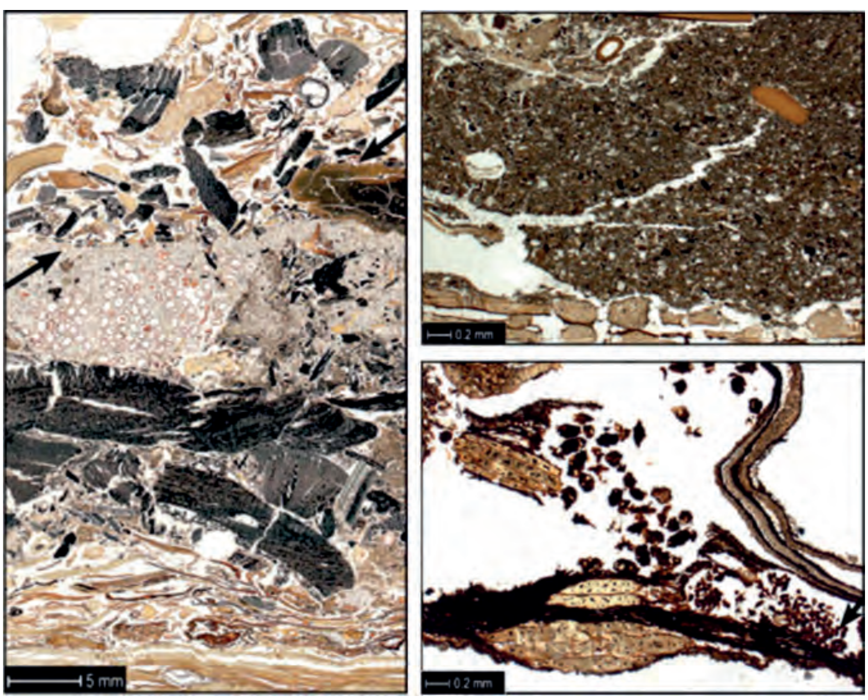


Fig. 1.38: left) An organic occupation deposit at the bottom is covered by a charcoal-rich burning layer and an accumulation of inwashed sand from the hinterland, mixed with lots of poppy seeds (disturbed on the right side). The top of the sandy layer is trampled (left arrow) and covered by charcoal, organic matter, and a burnt loam aggregate (right arrow). Arbon-Bleiche 3 M1030, PPL; right above) Homogeneous transgression deposit consisting of carbonate, fine sand, and clay containing reworked organic matter,microcharcoal, and bones. Arbon-Bleiche 3M1036, PPL; right below) Degraded wood remains with faecal pellets (center) and mite precipitation (arrow). Stansstad-Kehrsiten M440, PPL (from Ismail-Mayer, Rentzel, Wiemann 2013, 330, Figs. 9 E-F-H).

Traces of trampling in covered areas are not only characterised by horizontally skimmed clay floors; they also occur within finely stratified cultural layers from covered areas.

Despite positive results mentioned above, scholars pointed out also issues related to the micromorphological evidence of trampling in ductile waterlogged organic sediments, as the hardness to be identified (Ismail-Meyer et al. 2013). The high moisture content that characterises the deposit causes the sediment to swell quickly again after being walked on, with few irreversible signs of trampling being preserved (Ismail-Meyer & Rentzel 2004).

Furthermore, recently grown roots of reeds and rushes can penetrate from the shore into cultural layers, mixing them and changing the arrangement of remains, even if those are covered by 1–2 meters of lake marl (Haas & Magny 2004; Ismail-Meyer et al. 2013: 334). Post-depositional processes caused by reed growth can be seen, for instance, at the sites of Arbon-Bleiche 3 and at Cham-Eslen (Ismail-Meyer et al. 2013: 334). Changes in the spatial distribution of artefacts may be caused even by flooding processes and wave actions (more details in next paragraph). Finally, degradation and taphonomic processes can undermine the preservation of artefacts and ecofacts. The former are mostly subdued to surface's damages (polishing, bioturbation) and loss of material consistency, while organic materials are subjected to more invasive processes. These can include weathering and the depletion or humification of the organic material. The general excellent state of preservation of artefacts made from organic materials and ecofacts is possible thanks to their quick cover by water or because the components "were embedded in a water-satured environment and the preserved sediments never dried out after the material was deposited" (Wiemann & Rentzel 2015: 112); however, micromorphological studies on organic layers from lakeside settlements identified the presence of short-term flooding, which can lead to phenomena like erosion, re-deposition, displacement and modification of sediments embedding material evidence.

In this context, the balance between pH and redox potentials plays a crucial role: the pH provides the degree of acidity or alkalinity in a given substance, whereas the redox potential gives the level of oxidation or reduction in the soil. In the event of temporary dewatering of a waterlogged area, soluble minerals are oxidized and organic materials are more prone to degradation. Furthermore, certain organic materials showed level of preservation that varies according to different environmental conditions. For instance, bones are better preserved in both well-drained and waterlogged neutral to calcareous environments, but not in periodically wet ones. Conversely, parasite eggs thrive in these latter conditions and not in either well-drained or waterlogged ones (Menotti 2012: 228). Another important factor in the preservation of organic material in wetlands is the presence of bacteria: they are crucial for a large number of chemical processes especially in waterlogged soils. Two kinds of bacteria are attested: the aerobic, requiring oxygen for their metabolism while the anaerobic that do not need oxygen. The latter are divided into two further categories: facultative anaerobes which grow with or without oxygen and obligate anaerobes that grow only without it. Facultative anaerobes deplete the wetland oxygen, reducing the redox potential and creating anaerobic conditions, ideal for the preservation of organic material. However, they also contribute to the deterioration of some organic material, such as wood (Sikora & Keeney 1983; Freeman et al. 2004; Menotti 2012: 228).

5.1.2 NATURAL POST-DEPOSITIONAL PROCESSES IN A SEMI MICRO SCALE: THE LAKESIDE SETTLEMENTS PERSPECTIVE

Flooding processes may strongly affect the site dimension: although the double nature of this phenomenon (human action as natural factors), the analysis is there focused on the second scenario. These processes may have a seasonal or temporal character, producing lake-level transgressions, or a stable nature that involve the overflow of lakeside settlements/pile-dwellings. Climatic oscillations during the Holocene seem to have been the cause of important lake level changes; hydrological sensitivity of lakes themselves can also be involved in these fluctuations (Magny 1992a: 328). A lowering of the lake level, during longer phases of dry and warm climate, exposed platforms of lake marl or the previously deposited sediments (Schurrenberger et al. 2003); the latter may subsequently be re-covered by alluvium deposits or even eroded. Traces of water level changes are preserved into the archaeological record as layers of sand deposition, alternated with *couche de craie* (chalk's layers) as at Concise (Winiger 2008: 67). Runoff and high lake levels are caused by heavy rainfall and rapid snow melting, especially in temperate zones and mountainous areas. Major effects of flooding are erosion/outwash and redistribution of accumulations, as well as depositions of brought-in sediments from the lake itself or the hinterland (Turnbaugh 1978). When runoffs reach peatlands, unsaturated parts are quickly filled up but the catotelm is not influenced by this processes (Holden & Burt 2003; Baker et al. 2009). Runoff leads also to sediment transfer by surface flow from the hinterland and this sediment inflow from the catchment area occurs mainly during water discharge in spring (Mitsch & Gosselink 2007). High lake water tables may also lead to peat flooding and they too can be exposed to wave action; the consequence is erosion and removal of fine particles, leaving an aligned and well-sorted coarser substrate, such as sands and gravels (Keddy 2010). Flooding of lakeside settlements due to surface flow from the hinterland causes erosional processes within anthropogenic accumulations (Jacomet et al. 2004). In most cases the uppermost parts of organic cultural layers were affected by flooding: this fact probably is explained by the acrotelm-catotelm model. Whereas the acrotelm of organic accumulations was faster eroded, the dense waterlogged catotelm was not affected by the flooding and remained *in situ*. Lake flooding led to erosion and even to the removal of fine particles (Brochier 1983; Magny 2004b; Digerfeldt et al. 2007; Macphail et al. 2010); as pinpointed by scholars, in some cases lake flooding is combined with the deposition of micrite (Ismail-Meyer et al. 2013: 334). This presence may confirm that the sediment was probably transported to an area that underwent a further reworking due to a lake transgression; generally, lakeward parts of sites were more affected by lake flooding, while runoffs influenced more landward part of settlement (Jacomet 1985; Jacomet et al. 2004). These components, as micrite, big amounts of well-sorted fine sands, possibly mixed up with organic detritus and micro-charcoal, composed reworked layers. This is the case of both Zurich-Opera and Zug-Riedmatt that yielded layers, composed of micrite and fine detritus (Wiemann & Rentzel 2015: 111). Conversely, deposits that do not contain any freshwater indicators (as mollusc shells, oogonia, trichoptera larvae) can be considered as *in situ* if they contain fragile components, such as wood ashes or well-preserved coprolites (Huber & Ismail-Meyer 2012; Ismail-Meyer et al. 2013: 334). At Arbon-Bleiche 3 and at Stansstad-Kehrsiten all areas showed flooding markers and also parts that have not been reworked by flooding water (*Fig. 1.40*).

Subaerial weathering, or the depletion of organic material is attested at Zurich-Alpenquai and Zurich-Opera, where a "jelly-like transformation substance, which resembles dopplerite (Stolt & Lindbo 2010) had been formed and the presence of fungal spores, wood remnants and mite droppings in organic tissue confirm the occurrence of weathering processes" (Wiemann & Rentzel 2015: 111). Sediments with a strong limnic influence are quite common in Cham-Eslen: lake flooding led to erosion and reworking of anthropogenic sediments, but in the central part of the building, archaeological sediments could be considered as *in situ* (Huber & Bleicher 2009; Huber & Ismail-Meyer 2012) (*Fig. 1.41*).

All investigated sites are covered by limnic sediments indicating a final flooding event during, or shortly after, the abandonment (Jacomet 2004). This condition may avoid the quite destructive effect of a slow water rise that involves erosion caused by wave action (Goldberg & Macphail 2006: 114). This phenomenon, as well as currents in the littoral zone of lakeside settlements could

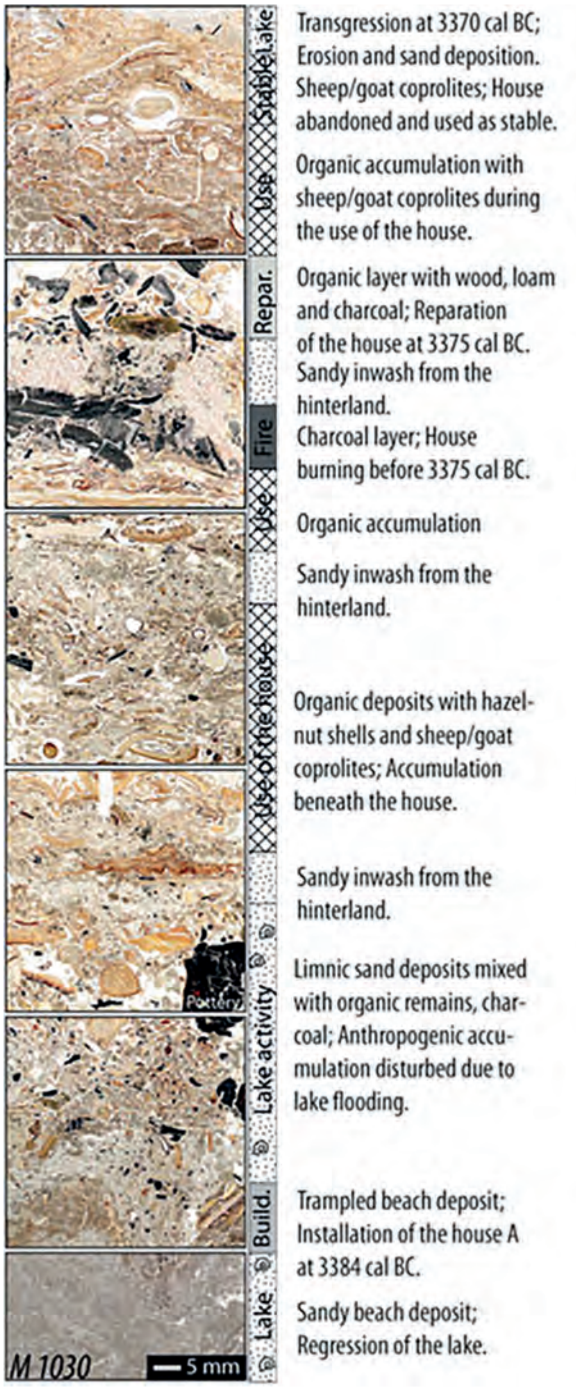


Fig. 1.40: The Arbon-Bleiche 3 thin sections of the column M 1030 with the micromorphologically recognised phases of installation, organic accumulations beneath the house floor and inwash of sand from the hinterland (from Ismail-Meyer, Rentzel, Wiemann 2013, 320, Fig. 2C).

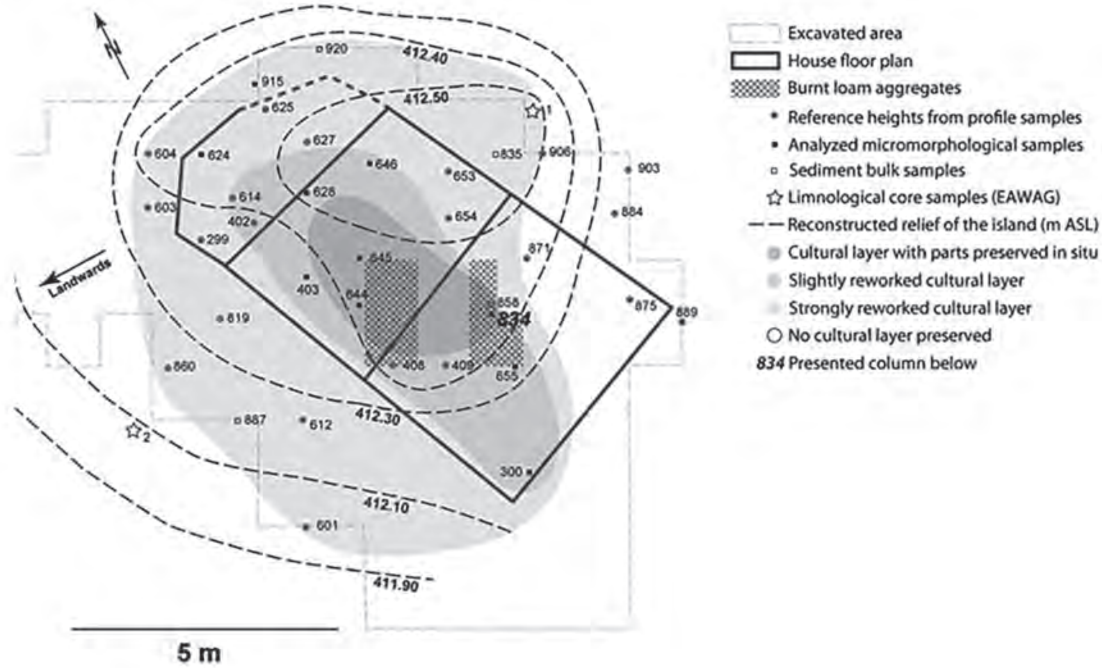
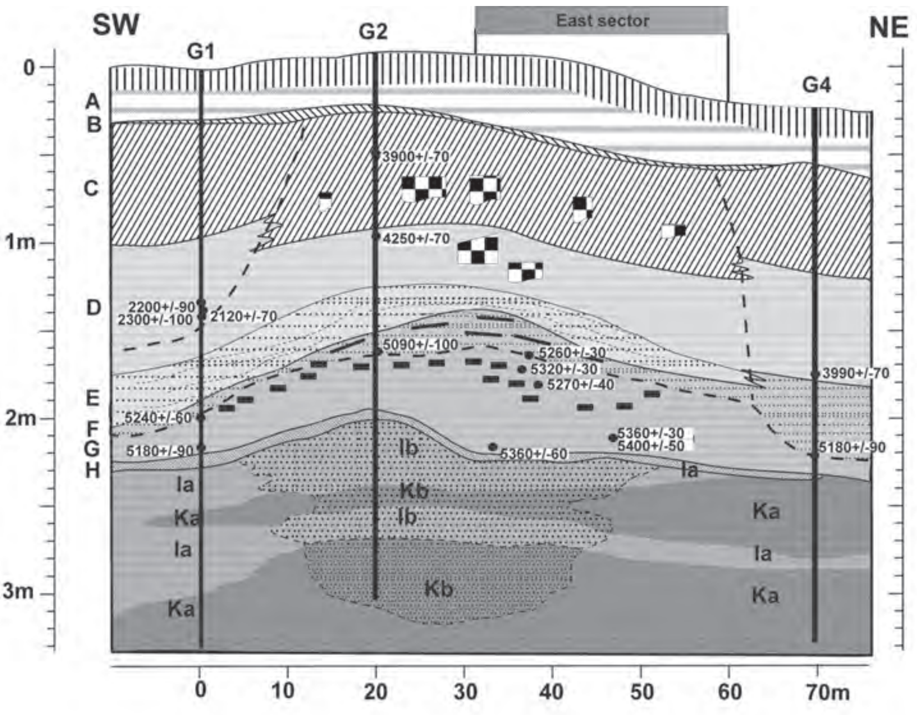


Fig. 1.41: Cham-Eslen, Overview of the site with the floor plan of the single house and the reconstruction of the small island. The house was constructed in the highest part of the island, but flooding led to reworking of parts of the cultural layer (from Ismail-Meyer, Rentzel, Wiemann 2013, 322, Fig. 3A).

cause reworking, reprocessing and sorting of lake marl. Original laminations are destroyed, terrigeneous detrital sand accumulates, mollusc shells are fragmented and algal filaments disconnected (Brochier 1983; Pétrequin & Magny 1986; Ostendorp 1990a; Ismail-Meyer & Rentzel 2004; Digerfeldt et al. 2007; Ismail-Meyer et al. 2013: 324). After the removal of finer particles, sand became enriched and a lag deposit was formed in the instance of a lake regression. Furthermore in some cases, as at Zug-Riedmatt, the overloading of several metres thick delta deposits led to a change in the organic layers (Gross et al. 2013). The wave action may affect the occupational layer of archaeological contexts that are not interested by dramatic fluctuation in lake level, as the open lakes. For instance, at Dispilo lakeside settlements, into the microfacies A, a mixing of materials from different occupational periods was attested as result of wave action (Karkanas et al. 2011: 109) (*Fig. 1.42*).

Some archaeological contexts from Constance Lake (Arbon-Bleiche 3, Hornastaad and Allensbach) showed a leaching of the fine matrix that took place during the Neolithic period and consequently sand beach deposits were formed (Ismail & Rentzel 2004; Ismail-Meyer et al. 2013: 323). At Mozartstrasse a leaching of organic materials is attested in the layer 1-c7 (Schmidheiny 2011: 37). Wave erosion may even prevent a further accumulation in the littoral zone: the progression of the shoreline and the formation of a flat surface can expand toward the centre of the lake with time (Magny 1978; Pétrequin & Magny 1986; Platt & Wright 1991; Magny 1992a; 1992b). Sandy layers produced by sediment input into it from the surrounding landscape, through increased erosion of dryland sediments and soils, are attested in some archaeological contexts; for instance, at Fondo Paviani, in the Profil 2, within the Unit 2, a pale brown alluvium, mostly clay-textured but grading laterally to silts and sandy silts is recovered (Nicosia et al. 2011: 284–5) (*Fig. 1.43*).

This alluvial episode took place after the early Iron Age local archaeological phase (post 9th century BC) on the basis of stratigraphic correlations with the site of Perteghelle (Balista et al. 2006, Fig. 2). The extensive alluvial cover is linked to the reactivation of spring-fed streams in the local paleo-river valleys during this time-span, determined most likely by climatic conditions. It is also accompanied by a phase of widespread soil erosion. This sand alluvial accumulations characterised even the upper stratigraphic sequence of several lakeside settlements: for instance, at Cisano (Salzani 1990; Balista & Leonardi 1996: 218), a low energy lacustrine deposit is attested, produced by sand movements from the surrounding landscape. Finally, the surface was made more compact by a strong erosion. This uppermost part of the archaeological record may also be partially modified by a



b

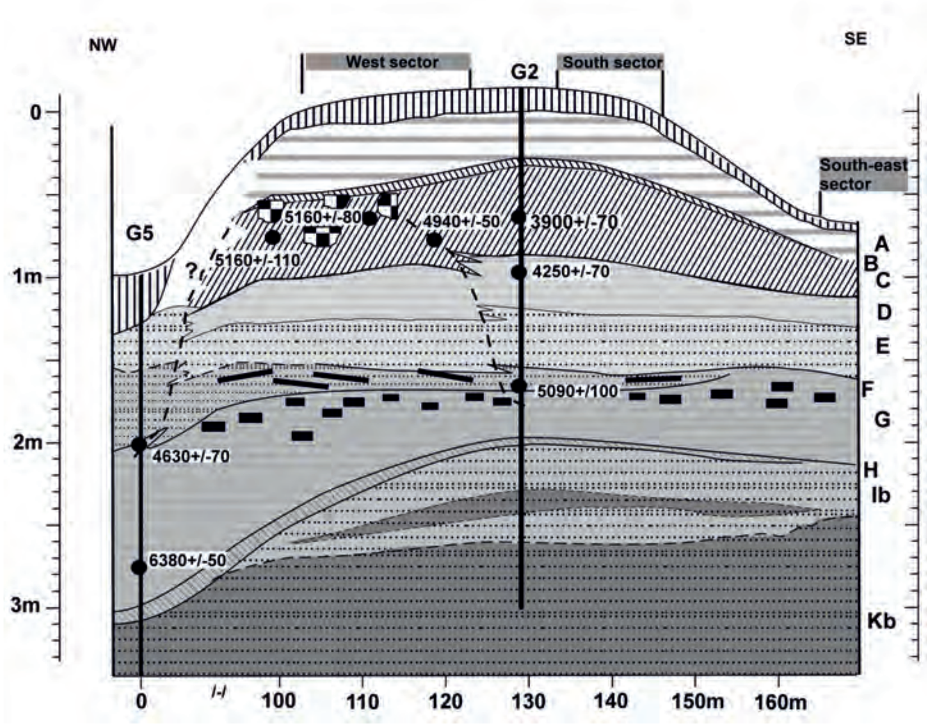


Fig. 1.42: a) Northeast-southwest section of the mound through cores DSG1, DSG2 and DSG4.; b) northwest-southeast section of the mound through cores DSG4 and DSG5 (from Karkanas et al. 2011, 92–93, Figs. 5 and 6).

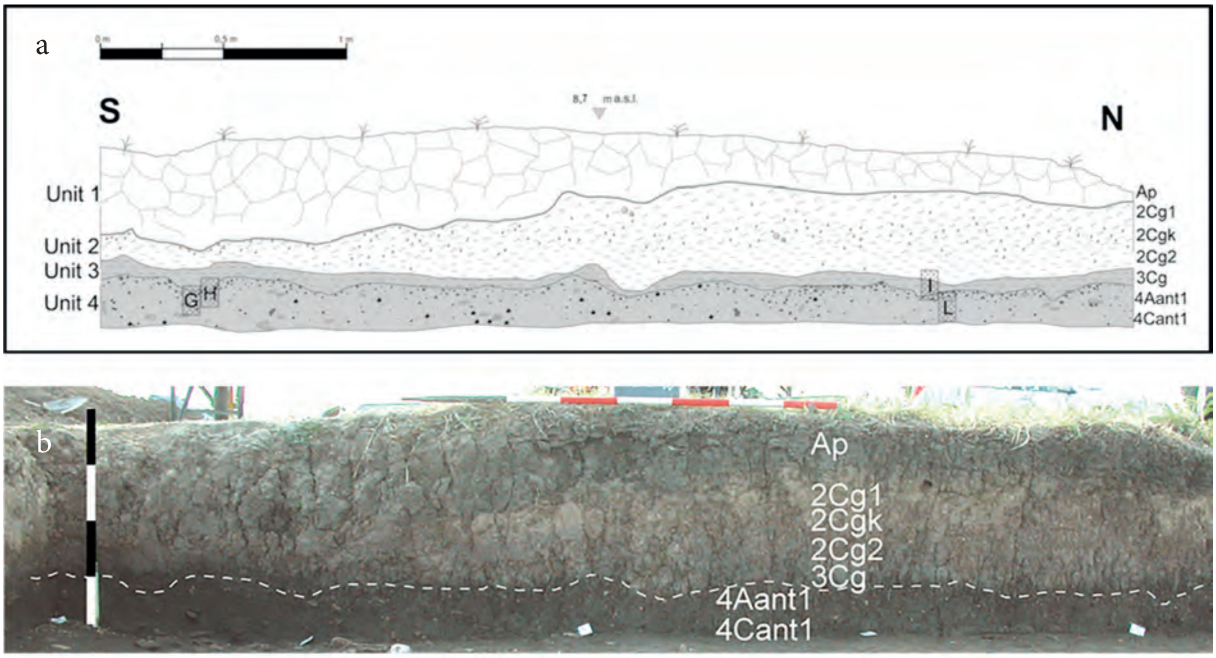


Fig. 1.43: Profile 2 with main litho-stratigraphic units (a) and pedogenic horizons (b) (from Nicosia et al 2011, 284, Figs. 6 and 7).

the action of recently grown roots of reeds (floralturbation); for instance, at Cortaillod-Les Esserts, roots occupied the north-western portion of the site already in 1927 (Arnold 1990: 95).

5.1.3 PEDOTURBATION PROCESSES IN A REGIONAL ANALYSIS SCALE

In wetland settlements quite all natural depositional and post-depositional processes affecting the site scale, influence somehow also the regional perspective. The lake-level fluctuations as well as the consequent erosion or the colluvial/alluvial accumulations that altered the archaeological record of each site, provoked a macro scale effect as showed by the case study of Fondo Paviani with regards to the Valli Veronesi, or by Neuchâtel Lake, Chalain and many more sites described in next pages. As cultural post-depositional processes also acted with similar effects, this perspective is highlighted at the end of the chapter, in order to show a complete overview.

5.2 CULTURAL POST-DEPOSITIONAL PROCESSES

The archaeological record can be altered as a result of cultural disturbance: major post-depositional effects on wetlands and lakeside settlements are due to human activities, such as agriculture, forestry, artificial lowering of lake levels, drainage systems, stream canalization, dam and dike constructions, mining, water pollution and groundwater extraction (Mitsch & Gosselink 2007; Ismail-Meyer et al. 2013: 334). They may influence the artefact scale, in terms of spatial distribution as well as material preservation, settlement dimension – referring to the material consequence of the modern drainage – and also consolidation, compression, oxidation and pedogenesis, which eventually destroys the wetland (French 2003; Lindsay 2010; Gastaldo & Demko 2011).

5.2.1 CULTURAL POST-DEPOSITIONAL PROCESSES: RECLAMATION AND SCAVENGING IN THE LAKESIDE SETTLEMENTS CONTEXT

Across the northern Circum-Alpine region, indications of settlement development are collected through dendrochronological dating. Since an asynchronous model of structures' construction and abandonment is attested (Jennings 2012, 2014), the presence of some archaeological objects as well as structures can be analysed according to a reclamation perspective. For instance, the reutilisation of recycled entire or quartered timber could have occurred between different settlements located in the neighbourhood, mostly in the case of planned abandonment. Indeed, if a catastrophic site's abandonment took place, it is not likely an intentional use of something that probably could be destroyed or left behind due to danger. The same perspective can be applied to old objects found within the Late Bronze Age settlements.

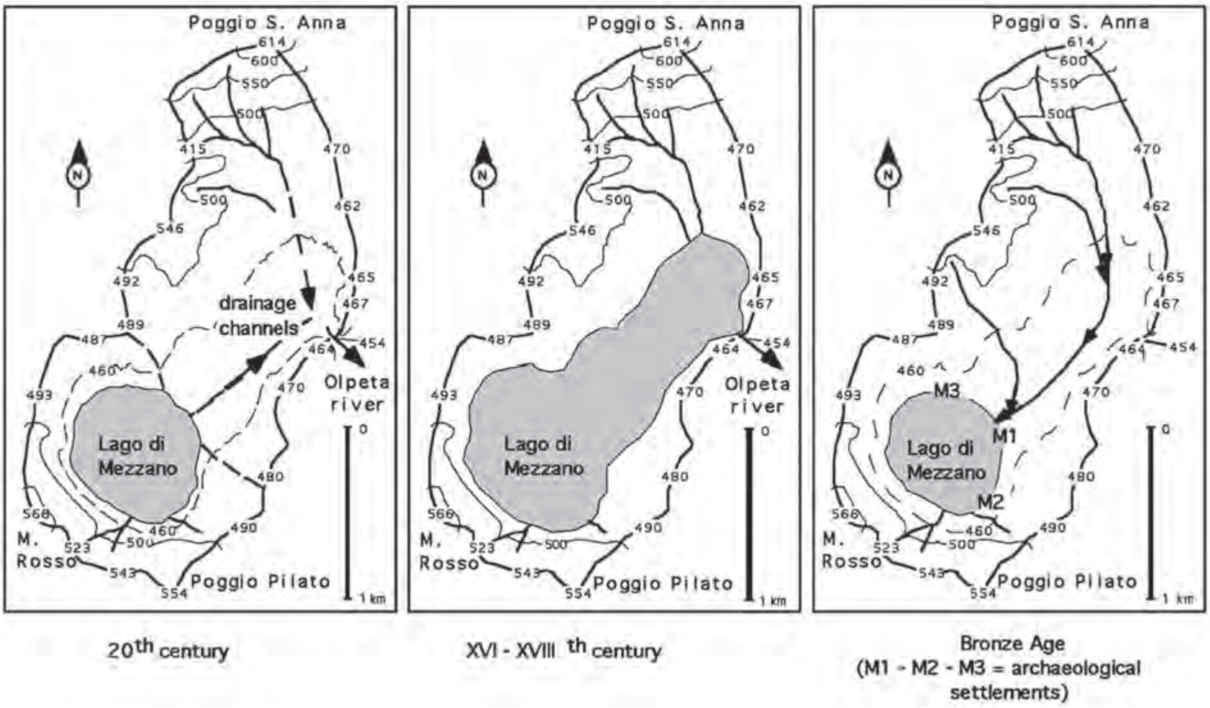


Fig. 1.44: The extension of Mezzano Lake size during three characteristic periods, present time, 16–17th centuries and Bronze Age. The 20th century extent of the lake was the result of reclamation works (from Sadori et al. 2004, 6, Fig. 2).

However, although this scenario is theoretically explainable, it cannot be confirmed archaeologically. Nevertheless, this is an interesting perspective that could be useful within the archaeological record of a single settlement. Furthermore, the possible other side of the coin has to take into account: the scavenging. During a post-abandonment phase, entire or fragmented objects left behind could be useful, if not as raw materials (for activities as well as building materials), as toys for kids, as highlighted in some ethnographical and archaeological analyses (Hayden & Cannon 1983; Deal 1985; Schiffer 1985: 987; LaMotta & Schiffer 1999; Cameron 2006).

5.2.2 CULTURAL POST-DEPOSITIONAL PROCESSES IN LAKESIDE SETTLEMENTS: THE DISTURBANCE

Modern drainage may be listed among the most invasive disturbance processes in case studies under analysis. Channels are often built in order to improve agricultural production or to control the water lake level. Drainage was carried out during the 15–17th centuries at Mezzano Lake (Sadori et al. 2004: 8) (*Fig. 1.44*), while at Ljubljansko barje (Turk & Veluščěk 2013: 183) draining operations were undertaken in the second half of the 18th century. The water-table has been artificially regulated for hydroelectricity production also at the Ledro Lake (Magny et al. 2009: 576), whereas at the Lucone Lake, that is currently a marshy area, a drainage work was realised in AD. 1459, in order to increase the cultivation area (Stegagno 1907; Valsecchi et al. 2006: 100). Fenland (England) represents one of the best examples of negative effects has on wetland environments, as Menotti suggested (Menotti 2012: 230). The intense drainage in the second half of the 19th century involved a shrank of peat surface of more than 3 metres in less than 50 years, as is shown by the famous Holme Fen posts (Menotti 2012: 230, Fig. 5.18, after Coles 1984: 28). Correction of the Swiss Jura's waters can be considered as one possible disturbance activity. This phenomenon consisted of a wide series of hydrological undertaking carried out in Switzerland in the region of three lakes: Morat Lake connected to Neuchâtel Lake by the Broye Canal, the latter connected to Bienne Lake by the Thielle Canal. These projects included operations of cleaning, restoration and diversion of rivers; the main works took place in three distinct phases during the 19th and 20th centuries. The correction has helped to regulate the hydrology, avoiding flooding and adding vast areas of valuable agricultural land. From an archaeological perspective, all these phenomena provoke a well-known dangerous process: the erosion. The strongest effects are attested in some lakeside settlements across the Neuchâtel Lake, at the Concise and at Cortalloid, although this phenomenon is quite widespread (for instance at Bourget Lake, Chalain Lake and Clairvaux, Paladru Lake (Isére) and Chens-sur-Léman (Haute-Savoie) (Pé-

Fig. 1.45: High rate of erosion attested at Cortaillod-Les Esserts (from Arnold 1990, 97, Fig. 79).

trequin & Pétrequin 1988). The higher rate of erosion is pinpointed at Cortaillod-Les Esserts, where up to 1,8 m of archaeological deposit has been washed away (Arnold 1990: 95) (*Fig. 1.45*). At Concise, the construction of a railway in the 19th century made erosion effects on the deposit even stronger. At Chalain Lake, water lake level has artificially dropped 12 meters due the employment of hydroelectricity. This sudden drop caused the instability of the banks: 10 hectares or more fell into the lake, causing the loss of nearly half of the lakeside settlements. The seasonal imbalance, artificially maintained, provoked a strong soil erosion, with the deposit being further deteriorated by the subsequent wild tourism. Bathers trampled archaeological deposits and exposed layers in shallow waters (Pétrequin & Pétrequin 1988: 188). In such a strongly affected area strategies were adopted to prevent the total loss of data; however, the analysis of such procedures is beyond the aims of this chapter.

Also all the modern intrusions can be considered post-sedimentary C-transforms: for instance, at Zurich-Opera the settlement area has been covered by deposits linked with the construction of an embankment in 19th century and the organic layers had to bear a heavy load, with a consequent strong compaction of the organic layers (Wiemann & Rentzel 2015: 111). In the same way a strong modification has been represented by the artificial sinking of the level of Lake Zug performed at Risch-Oberrisch (Hochuli et al. 2010).

Modern cultivation practices are further factor of influence in the preservation degree of the archaeological record, in particular respect to the upper layers. A first arable level 50 cm deep was found in the LAV1 core (from Lavagnone) (De Marinis et al. 2005: 228), while at Lucone, two cores (Luc-1 and Luc-2) showed traces of ploughing disturbance in the first 90 cm of deposit (Valsecchi et al. 2006: 101). Partial destroyed surfaces characterised some Terramare, as Montale (Mercuri et al. 2006: 44, 46) and Gaggio di Castelfranco (Balista et al. 2008). Indeed, their dark-coloured archaeological deposits were intensively quarried beginning in the late 18th century to be used as soil fertilizer on fields, particularly those devoted to the production of fodder for bovines (Conversi & Mutti 2009; Bernabò Brea & Mutti 1994; Nicosia et al. 2011: 280). Such deposits were erroneously thought to improve the chemical fertility of local soils due to their high content of organic carbon, nitrogen and phosphorous deriving from human activities. The land deprived of its original vegetation through ploughing and forest clearance for cultivation practices produced intense aerial erosion, as attested in some archaeological contexts from the Po Plain (Marchetti 2002 (cf. Bernabò Brea et al. 1997) and Grandi Valli Veronesi area (among others Fondo Paviani (Balista et al. 2006; Nicosia et al. 2011) and Fabbrica dei Soci (Balista 1990–1991) (Nicosia et al. 2011: 290).

The process of forest clearing and agriculture strengthened the outwash of sands and silts, that provoked a transport of detached sediments downslope and their deposition in the bottomlands (Turnbaugh 1978; French 2003; Zolitschka et al. 2003). This in-wash process certainly occurred also within lakeside settlements. In Arbon-Bleiche 3, earlier beach deposits in the hinterland were eroded in this way and this process of colluviation (triggered by heavy rainfall) was even noticed during the excavation of the archaeological site (Leuzinger, personal communication, 2003 quoted by Ismail-Meyer et al. 2013:325). Modification of shores are attested at the Banyoles Lake (La Draga) and at Zurich Lake (Mozartstrasse): in the first case earthworks carried out in preparing the lake as a host venue for the 1992 Olympic Games have impacted the site. The level 0 consisted of a deposition of rubble, while the levels I to III are constituted of a set of dark clays in which surface disturbance and intrusions of modern materials have been detected, as a consequence of agricultural works developed in the area until 1989 (Palomo et al. 2014: 61). At Lucone A Middle Bronze Age levels have been most completely destroyed by recent agriculture: material evidence dated to this time-span have been retrieved mixed within the modern agrarian soil or immediately below (Baioni et al. 2007: 88). At Zurich Lake the bay shores were modified in order to gain building land and its immediate vicinity is today rather different from how it looked during prehistoric times (Jäckli 1990). The Early Bronze Age settlement of ZH-Mozartstrasse was situated on the little peninsula which, because of in-filling processes, has completely disappeared. The site today is underneath the Bernhard Theatre in the north-western part of Zurich bay and its surviving Early Bronze Age anthropogenic stratum lies at about 60–70 metres from the present shoreline at an altitude between 403 and 404 metres a.s.l. (Menotti 1999: 147).

5.3 NATURAL AND CULTURAL POST-DEPOSITIONAL PROCESSES: "DIVERSITY IN UNITY"

This short overview of the most widespread post-depositional processes that may alter the lakeside settlements contexts suggested what archaeologists had already hypothesised from the early 1980: these deformation processes are mainly due to erosion. The cause of the increase in erosion is twofold: a marked change in climatic conditions (natural reasons) as well as an increase in human activity around lakes. Together these causes have created an exaggerated effect of erosion that has been destroying natural and cultural heritage in and around lacustrine areas. Particularly affected by this phenomenon is, as mentioned, the Circum-Alpine region and its surroundings, where a large number of lake-shore archaeological sites have already been lost due to erosion over past thirty years. On Geneva Lake for instance, a survey carried out between 1981 and 1985 showed that only a dozen settlements (out of over sixty) still retained anthropogenic layers in place (Ramseyer & Rouliére-Lambert 1996, 2006; Menotti 2012: 232). In order to reconstruct deformation processes that produced our archaeological record, a strategy based on "diversity in unity" is proposed as the most useful approach: combined analysis of cultural and natural post-depositional processes could constitute an interpretative response to the changing material evidence of our archaeological context. Despite this imbalance can be triggered by natural phenomena, anthropogenic factors are mostly to be blamed; short-term reductions may be allowed, providing that the soil has sufficient water-retentive characteristics, but long-term may cause serious problems (Menotti 2012: 226).

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2. THE LJUBLJANSKO BARJE, SLOVENIA

Anton VELUŠČEK

2.1 INTRODUCTION

The Ljubljansko barje is a river floodplain southwest of Ljubljana. The wet central part covers a little more than 160 km^2 (*Fig. 2.1*). In the final millennia of the Pleistocene and during a large part of the Holocene, it held a lake that became completely overgrown by marshes by the end of the 2nd millennium BC. Since then, many watercourses have gained importance.

The Ljubljanica river is the largest of them. From its karst sources in the west, it flows through the central part of the Ljubljansko barje towards Grajski hrib, where it cuts into the gravel deposits of the river Sava, into which it discharges at Zalog. With the drainage works and the extraction of the thick peat layers, the latter especially intensively in the 19th and early 20th centuries, the wetland was converted into agricultural land. Today, due to the abandonment of fields, meadows slightly predominate (Pavšič 1989; Lovrenčak & Orožen Adamič 2001: 380-390).

In prehistoric archaeology, the Ljubljansko barje is known primarily for two phenomena. The first is the pile-dwelling settlements that dotted the area with interruptions from the middle of the 5th to the second half of the 2nd millennium BC (Velušček 2004a; Velušček, Čufar 2014). The Ljubljanica river and its tributaries are another phenomenon. At least since the Middle Bronze Age, it has been considered a cult landscape and later an important traffic route, which gained importance especially after the first contacts with Roman traders (Turk et al. 2009; Čufar, Merela, Erič 2014; Erič et al. 2014).

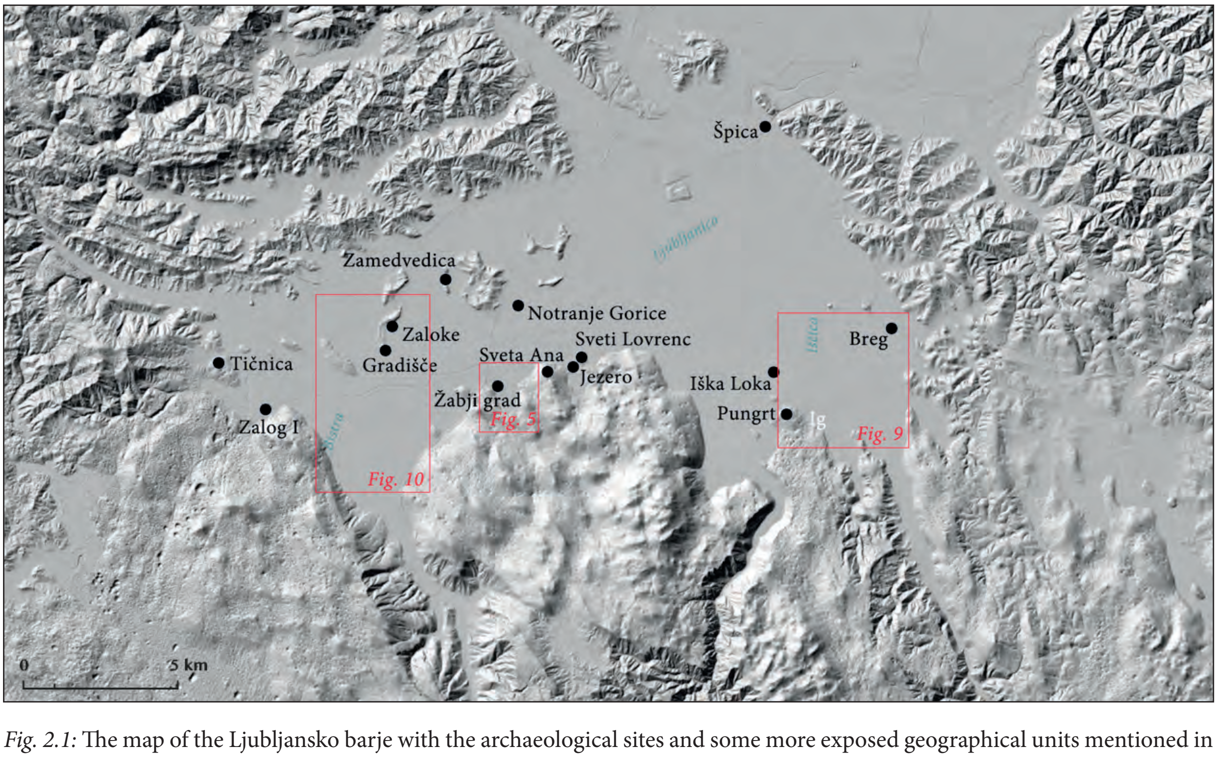

Fig. 2.1: The map of the Ljubljansko barje with the archaeological sites and some more exposed geographical units mentioned in the text. (Elaborated by Tamara Korošec; source © ARSO.)

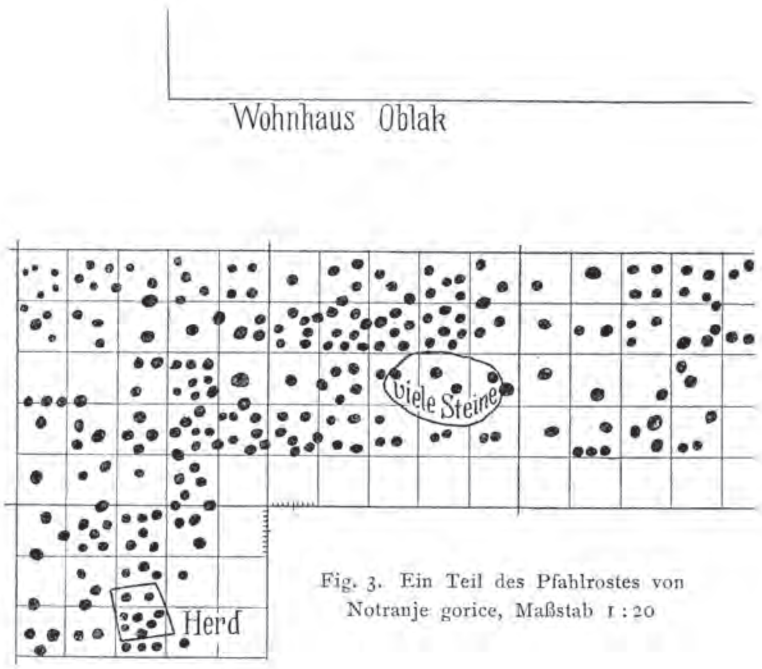

Fig. 2.2: Walter Schmid's site plan drawn up during the research work in 1907 and 1908 at the Notranje Gorice pile-dwelling site (after Schmid 1910: Fig. 3).

The first archaeological finds indicating prehistoric settlement in the wetland were found in the mid-19th century, when the Südbahn/Južna železnica ('Southern Railway') was built across the Ljubljansko barje. It was at this time that the first pile dwellings were discovered in Switzerland, the fame of which also aroused scientific and public interest in Slovenia (e.g. Hitzinger 1857). Contemporaneously with a pile-dwelling settlement being found on the former island in Lake Keutschach, in Carinthia, a topographical survey was also carried out in the Ljubljansko barje in 1864 (Hochstetter 1865), though the first similar site was detected in 1875 north of Brunndorf/Studenec, nowadays the village of Ig, where in this year and in the next two years extensive archaeological excavations took place under the direction of Karl Deschmann. He investigated three pile-dwelling sites that became known as Deschmann pile-dwelling settlements I–III. Being an expert in many fields of the natural sciences, macrobotanical and archaeozoological remains were collected and at least some even identified. As a pioneer of archaeological research in Slovenia, he used research methods similar to those used in geology. Excavation documentation was very rudimentary. The most valuble document is a site plan that Peruzzi made in the 1875 research season, which shows a batch of several thousand piles and, in the corner, a profile through the soil layers (Vuga 1989, 2002). Covering more than 12,000 m^2 (Leghissa 2020: 20), his excavations are the largest ever in the Ljubljansko barje wetlands.

Among the officially registered investigations, we should also mention the research of Walter Schmid. In 1907 and 1908, he excavated the remains of pile dwellings in a small bay at the northern edge of the wetland, at the foot of an isolated hill in Notranje Gorice (*Fig. 2.1*) (Schmid 1910). The excavation site was not as extensive as that at Ig, but the site plan shows a clear progress in the documentation of archaeological structures; there were still inaccuracies, but the site was divided into a square grid (*Fig. 2.2*).

Schmid departed for Graz, Austria, in 1911 and a long research hiatus ensued. It took about 30 years before a new attempt at archaeological fieldwork was undertaken, very soon interrupted by unfavourable weather conditions and the outbreak of World War II (Velušček 1997a). Nevertheless, the popular Slovenian term 'kolišče' for a pile-dwelling settlement was introduced into the scientific literature during this period, and the definition of the prehistoric wetland settlements in the Ljubljansko barje was also proposed (Ložar 1931: 25, 1941a: 4).

After the war, Josip Korošec became professor of prehistory and early Slavic archaeology at the newly established Department of Archaeology at the University of Ljubljana and continued research on the prehistoric wetland settlements. In 1953, he investigated at Blatna Brezovica (Korošec 1963). Unfortunately, Korošec applied only seemingly better excavation methods than the researchers at the beginning of the century. The description of the layers and other important data were very superficial. Special attention was paid to the number of piles in a 4 m grid square (e.g. Korošec 1963: 11), whereas the stratigraphic relationships between finds, structures and layers were almost neglected. The muddy soil in the excavation site, which was trampled underfoot, was not very promising anyway. An important achievement was the involvement of experts from the natural sciences in the research. Thus, a palaeobotanist identified the scattered plant remains and especially the samples of piles (cf. Šercelj 1981-1982: 102-103).

Applying comparable research methods, excavations at Resnikov prekop followed in the second half of the 1950s and again in 1962 (Bergant 1964; Harej 1975). In addition, four pits were dug in a 2 m grid square to a depth of two metres per day as part of the Ig trial trenching project in 1963 (Bregant 1964-1965). A participant in the trial trenching noted it often happened that the trench walls collapsed very quickly, which made documentation difficult or impossible (after Leghissa 2017a, 32; also see Bregant 1964-1965: 179-180). Nevertheless, some trenches did make it possible to identify the exact location of the sites that Deschmann had excavated between 1875 and 1877.

Maharski prekop, covering 1208 m^2, was the site of the most extensive research of any pile-dwelling settlement in the Ljubljansko barje in modern history (cf. Bregant 1996). Excavations in the wetland north of the village of Ig took place between 1970 and 1977. In addition to the main research area, small-scale trial trenching was carried out at several locations on the nearby meadows (Bregant 1975: 107). The excavation methods remained similar to those employed previously. The archaeological finds were mostly documented in 4 m grid squares (Bregant 1974a, 1974b, 1975). Blocks of sediment were cut, transported to the edge of the excavation site and subsequently examined (Velušček 2013: 390). Several profiles that crossed the entire excavation area were documented during the campaign and provided important stratigraphic data. Unfortunately, only some of the ground plans were recorded and rarely the exact stratigraphic data of the finds (artefacts, piles, etc.).

An enormous step forward was the significant integration of the natural sciences into the research. Besides the archaeozoological (Drobne 1974: 1975) and palaeobotanical (Šercelj 1974a, 1974b, 1975) studies, the first analyses of the raw material for pottery production (Osterc 1975) were carried out and soil data collected. The calcium carbonate, potassium and especially phosphorus content was measured, the value of which increases significantly in the layers where anthropogenic residues are present (Stritar 1975).

Most surprising was the absence of dendrochronology, which was practised at that time in the research of lakeshore sites, especially in countries north of the Alps (Billamboz 2004). This had a significant impact on the interpretation of the excavation results (see Bregant 1996). Consequently, the prehistoric settlement at Maharski prekop was dated using the typological analysis of pottery finds (Bregant 1974a, 1974b, 1975). Due to the presumed lower-quality and predominantly undecorated pottery, it was assumed that the settlement represented a decline in the cultural development of pile dwellings in the Ljubljansko barje. A date to the Early Bronze Age, which was little known at that time, was therefore suggested as a pragmatic solution (Bregant 1974a: 36; see also Gabrovec 1983: 27).

However, the proposed age did not match the results of the radiocarbon dating (Bregant 1975: 114; also see Gabrovec 1983: 28), which clearly indicated an earlier date of the sampled piles and the site, most likely the 4th millennium BC. The discrepancy was resolved in 1984 by Hermann Parzinger, who used a typological analysis of the pottery to classify the settlement at Maharski prekop in the early and developed stages of the Baden culture in the Middle Danube region.

Extensive research was carried out at Parte in the late 1970s and early 1980s. The excavation site was located near the spot by the river Iščica, where the remains of Deschmann's third pile-dwelling settlement (Deschmann III) were investigated in 1877 (*Fig. 2.7*) (see Velušček 1997b; Leghissa 2021: Fig. 1). The research method was comparable to that used at Maharski prekop. The excavation site measured 640 m^2. Pottery finds were documented in 4 m grid squares following arbitrary levels that could reach a thickness of 130 cm, but mostly in thinner horizontal units expressed in depths below the surrounding surface, such as 210-180 cm, 180-150 cm, 150-120 cm and 120-110 cm. Profiles were documented for each excavation year (Harej 1978, 1981-1982, 1987).

Hundreds of kilograms of sediment from the presumed cultural layer were wet-sieved and yielded a large number of seeds.[1] Among them were several hundred seeds of grapevine (*Vitis vinifera* ssp. *sylvestris*), which were at the time the earliest in Slovenia (Šercelj 1981-1982: 104). The value of calcium carbonate, phosphorus and other elements associated with the layer rich in anthropogenic remains (Stritar & Lobnik 1985) was measured. The wood used for the stilts was also identified, with ash and oak predominating (e.g. Šercelj 1981-1982: 106). Several pile samples were sent to the ^{14}C laboratory in Zagreb for radiocarbon dating and the results, with a very high standard error, showed the settlement roughly dated to the middle of the 3rd millennium, which corresponded to the Late Vučedol culture (Harej 1978: 74, 1981-1982: 46; e.g. see Forenbaher 1993).

At the end of the 1980s, a preventive archaeological research was carried out at the Konec site (*Fig. 2.10*), east of the isolated hill of Blatna Brezovica, where a few piles indicated a prehistoric settlement or even a pile-

[1] Animal bones were also collected but have remained unpublished.

dwelling settlement. The reason for the small number of architectural remains was sought in the possibility that trenches were located at the edge of the settlement area. In spite of this, experts welcomed the excavation results due to the ceramic finds attributable to the Early Bronze Age, an age confirmed by the ^{14}C date falling to the end of the 3rd millennium (Dirjec 1991).

At the beginning of the 1990s, during the institutionalisation of the independent Republic of Slovenia, research on pile dwellings, wetland archaeology and interest in the prehistory of the Ljubljansko barje ceased for a while due to the change of generations of researchers. Then, in the mid-1990s, Mihael Budja published a paper in which he partially denied the existence of pile dwellings in the Ljubljansko barje (Budja 1994). According to him, sites such as the 5th millennium BC Resnikov prekop and presumably the 5th and 4th millennium BC Maharski prekop[2] were dry land settlements on the river bank, and not lakeshore pile dwellings.

After several decades, the Institute of Archaeology ZRC SAZU resumed its research in the wetland of the Ljubljansko barje in 1995. In cooperation with the Department of Wood Science at the University of Ljubljana, dendrochronology was introduced into the research, which significantly changed the prevailing view on the prehistoric settlement of wetlands in Slovenia (e.g. Čufar et al. 1997; Čufar, Velušček, Kromer 2013).

The research began with a settlement analysis and comprehensive archaeological topography of the wetland of the Ljubljansko barje. The scientific literature and some archives were also reviewed (Velušček 1997a, 1997b). The Institute has re-established the annual inspections of the drainage works in cleaning the main ditches, which are systematically carried out by services on the commission of the Ministry of Environment and Spatial Planning of the Republic of Slovenia. This led to the discovery of new pile-dwelling sites such as Črešnja pri Bistri, Dušanovo and Trebež (*Fig. 2.10*). Samples of piles for dendrochronological analyses were taken where ditches and canals intersect prehistoric settlements, for example at Založnica, Hočevarica, Resnikov prekop, Stare gmajne, Črešnja pri Bistri, Dušanovo, Trebež and Strojanova voda. Piles were also sampled in the Iščica riverbed at the Spodnje mostišče and Parte-Iščica sites, and at Parte, Blatna Brezovica and Maharski prekop which had been systematically investigated many years earlier.

Trial trenches were dug at Hočevarica (1998), Stare gmajne (several times between 2002 and 2021) and Resnikov prekop (2002). The location of the trenches, one in Hočevarica and three in Resnikov prekop, was determined by manual drilling to estimate the depth, presence and possible richness of the cultural layer.

Not far from the confluence of the river Borovniščica with the Ljubljanica, remains of piles, animal bones and prehistoric pottery were discovered at Blato that indicated a pile-dwelling settlement (*Fig. 2.10*). The preliminary dating of the pottery points to the Late Middle Bronze Age or beginning of the Late Bronze Age. The Blato site is the youngest currently known pile-dwelling settlement in the Ljubljansko barje (Velušček, Toškan, Čufar 2011).

Since the 1990s, the Department of Archaeology at the University of Ljubljana has focused their investigation efforts in the area north and north-east of Ig, where there are many prehistoric settlement (pile-dwelling) sites from Resnikov prekop to Spodnje mostišče (*Figs. 3* and *9*). They drilled several boreholes and excavated some test trenches. Technologies such as GIS and later LIDAR were used for data analysis. Geophysical surveys were also introduced (e.g. Mlekuž, Mušič, Medarič 2014; Mori & Mlekuž 2018; Horn, Mušič, Mlekuž 2021).

This research has produced some very surprising interpretations, which some (see Velušček 1997b, 2007, 2013; Velušček & Čufar 2008; Čufar et al. 2015) see as contradicting the known data. For example, the interpretation of the results of the last research campaign marks two settlements from the 4th millennium BC on the map (see VirtualArch 2020: minutes 15:35-18:35; Horn, Mušič, Mlekuž 2021: Fig. 1a). The southernmost, which appears to be a smaller settlement, has been proposed for the Gornje mostišče site. The second settlement is much larger and connects the sites of Maharski prekop and partially Spodnje mostišče including the intermediate zone between them (Horn, Mušič, Mlekuž 2021: Fig. 1b-d; VirtualArch 2020).

The data obtained so far show a different picture. Northeast of the village of Ig, approximately between the river Iščica and the drainage canal Strojanova voda, four archaeological sites were discovered with remains of chronologically different pile-dwelling settlements from the 4th millennium BC (*Fig. 2.3*)[3]. According to the ^{14}C data, dendrochronological analyses and cultural assignment of artefacts, the earliest settlements are at Gornje mostišče and Strojanova voda (e.g. Velušček & Čufar 2008; Mlekuž, Mušič, Medarič 2014; Tolar 2018). Both are representatives of the Furchenstich (stab-and-drag) pottery culture and dated to the first half of the 4th millennium BC. At Gornje mostišče, piles with characteristic pottery finds were also found and/or reported from the fields on the opposite side of country road

[2] The dating of the Maharski prekop site has long been the subject of debate (e.g. Bregant 1975; Parzinger 1984; Budja 1994; Mlekuž, Budja, Ogrinc 2006; Velušček 2009a). Notably, there were many attempts to date the site to the second half of the 5th millennium BC, which has no support in the pottery finds discovered so far that, in contrast, clearly place the settlement in the 4th millennium BC (e.g. Velušček 2013; Čufar et al. 2015).

[3] The site of Resnikov prekop (see its position at e.g. Horn, Mušič, Mlekuž 2021: Fig. 1a) is earlier. It is dated roughly to the middle of the 5th millennium BC (cf. Velušček 2006b).

(cf. Velušček 1997b; Velušček & Čufar 2008), but this situation was not detected at all during the geophysical survey (cf. Horn, Mušič, Mlekuž 2021: Fig. 1a-d) (*Fig. 2.4*). The site of Strojanova voda (*Fig. 2.3*), possibly the largest settlement of the group, is also missing on the above-mentioned map (see Horn, Mušič, Mlekuž 2021: Fig. 1a; VirtualArch 2020; cf. Velušček 1997b; Velušček & Čufar 2008; Tolar 2018). The occupation was followed

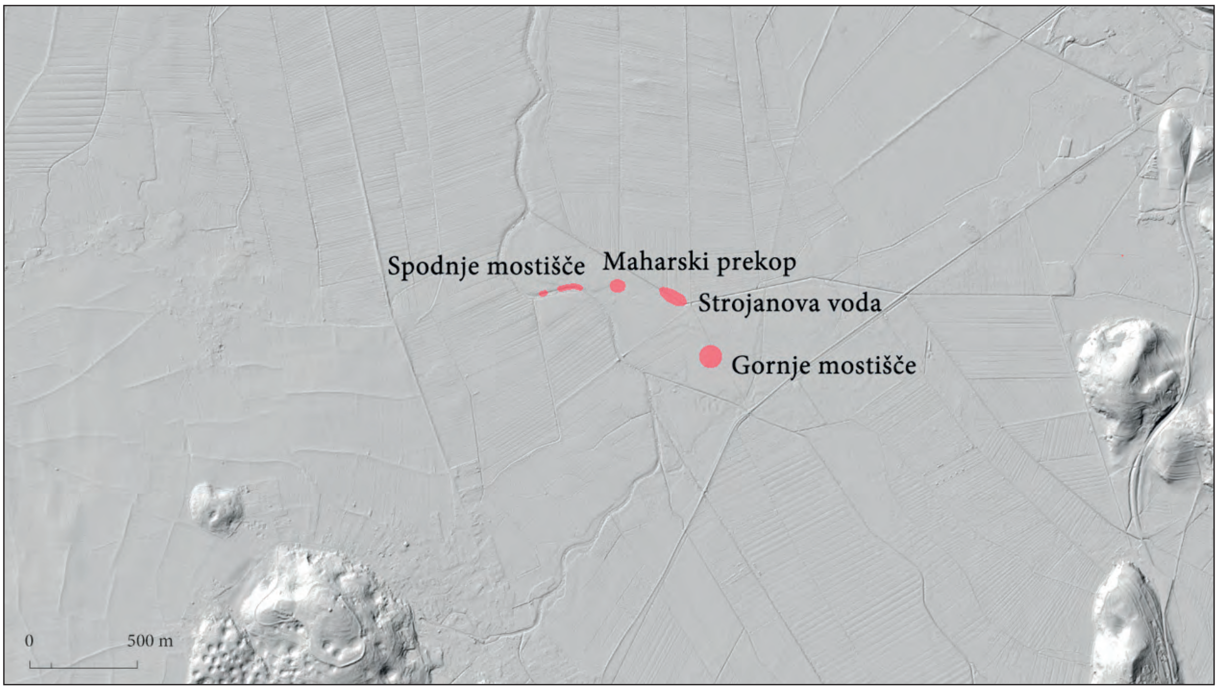

Fig. 2.3: The archaeological zone northeast of the village of Ig in the Ljubljansko barje with marked locations of the pile-dwelling sites from the 4th millennium BC. (Elaborated by Tamara Korošec; source © ARSO.)

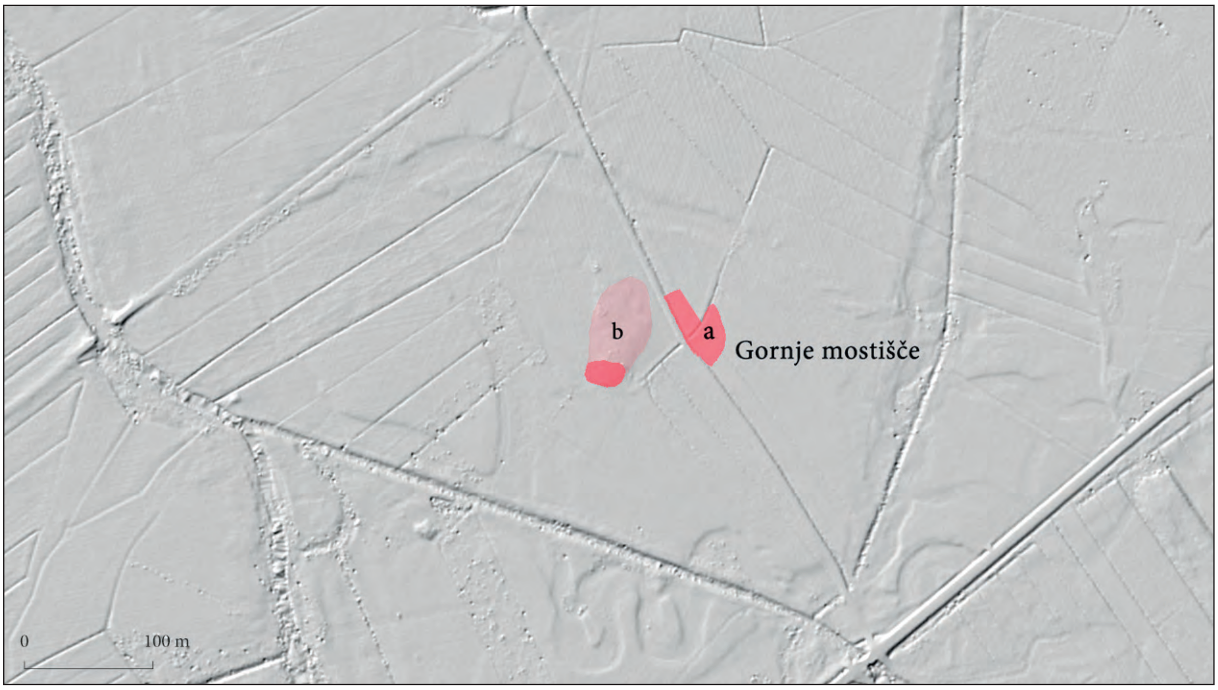

Fig. 2.4: The archaeological site of Gornje mostišče with a) marked locations of recorded pottery finds, piles and other archaeological features (from Velušček 1997b) and b) research area of the Dimitrij Mlekuž's research group (Mlekuž, Mušič, Medarič 2014; Horn, Mušič, Mlekuž 2021: Fig. 1a-d). Trenching or survey with confirmd archaeological finds (red), geophysical survey (pale red). (Elaborated by Tamara Korošec; source © ARSO.)

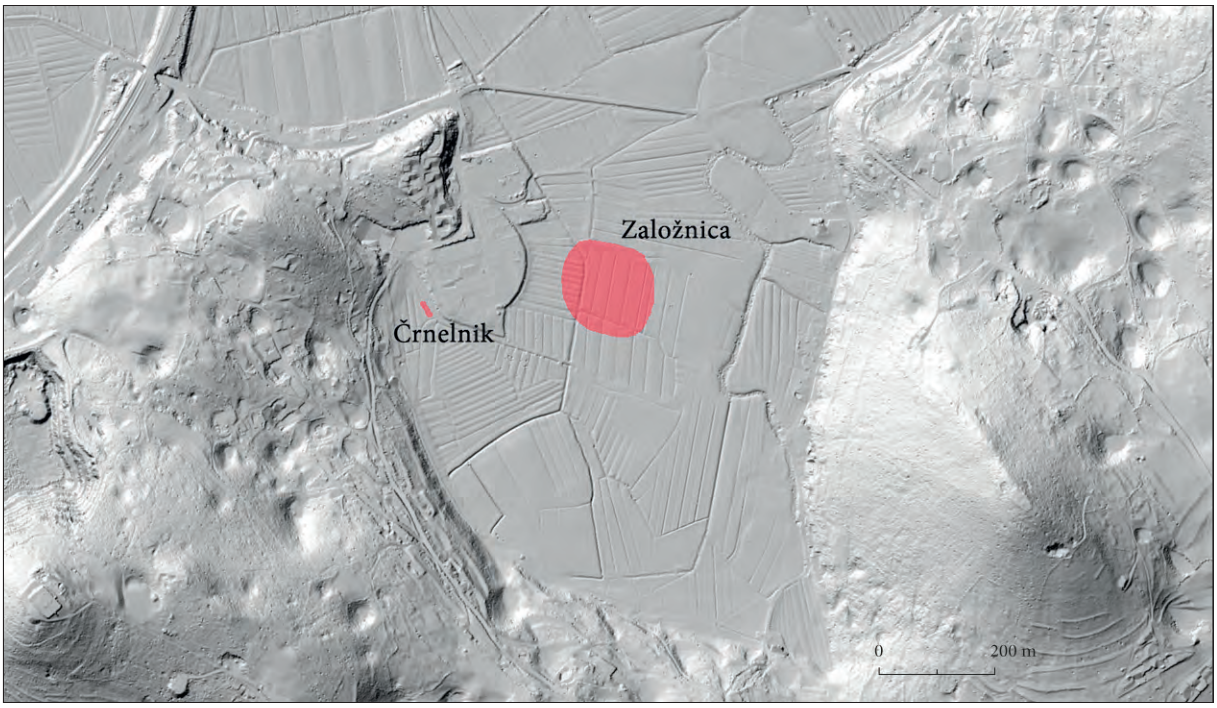

Fig. 2.5: The archaeological zone in a bay south of the central part of the Ljubljansko barje with two sites of pile-dwelling settlements. (Elaborated by Tamara Korošec; source © ARSO.)

by settlements attributed to the Stare gmajne cultural group. In the area a little further to the north-west, two sites are known at a distance of about 200 metres from one another: Maharski prekop and Spodnje mostišče (*Fig. 2.3*). The later settlements at Maharski prekop and Spodnje mostišče, which are interpreted as a single large settlement in the VirtualArch 2020 movie, were not contemporaneous[4], so they cannot represent one settlement as proposed. If the estimate of the research group is realistic, we are dealing with dozens or perhaps even more contemporary houses in this area. One would therefore expect an increased human impact on the environment, which would be evident from the pollen diagrams, but this is not the case (e.g. cf. Gardner 1997; Andrič et al. 2008; Andrič 2009).

The Department of Archaeology at the University of Ljubljana also carried out excavations at Zaloke (*Fig. 2.1*), east of the village of Bevke and the isolated hill of the same name. They unearthed a multi-period site dated to the end of the 3rd millennium (beginning of the BA A1 phase) and the transitional BA C/D phase. According to the lead researcher, the lack of archaeological finds and structures suggests that the excavation site lay outside the main area of the prehistoric settlement (Črešnar 2014).

The excavation of the Špica site (*Fig. 2.1*), already discovered at the end of the 19th century (Velušček 1997b) though almost nothing was known about it, attracted a lot of public attention during the research that the Ljubljana City Museum conducted in 2009 and 2010. It revealed a settlement area mainly inhabited in the 3rd millennium BC and archaeological finds attributed to the Vučedol, Ljubljana and Somogyvár-Vinkovci cultures often compared with Deschmann's finds in the pile dwellings near Ig (Klasinc et al. 2010; Šinkovec 2012).

In 2014, a group of archaeologists led by *MAGELAN skupina* LLC conducted archaeological investigations along the sewage pipeline near Kamnik pod Krimom. South of the industrial facilities along the Črnelnik ditch, on the edge of the southernmost bay of the central Ljubljansko barje, they found the remains of a pile-dwelling settlement from the first half of the 4th millennium (*Fig. 2.5*) (Velušček et al. 2018).

Also important is the research of the Underwater Archaeology Group at the Institute for the Protection of the Cultural Heritage of Slovenia (ZVKDS). They documented numerous archaeological finds in the riverbeds of the Ljubljanica and its tributaries, some of which can be traced back to the Copper Age (e.g. Turk et al. 2009; Erjavec & Gaspari 2012). The pile-dwelling site at Veliki Otavnik Ib was found in the river Bistra,

[4] The Maharski prekop site was intensely inhabited in the first half of the 35th century BC, with some presumed signs of activity at the end of the same century. In contrast, the main habitation phase at Spodnje mostišče can be dated to the first half of the 34th century BC, while habitation here could have begun at the end of the 35th century (see Velušček & Čufar 2008; Čufar et al. 2015).

a tributary of the Ljubljanica (*Fig. 2.10*). Artefacts and piles dated it to the second half of the 4th millennium (Gaspari et al. 2009). Also found was a settlement at Mali Otavnik dated to the Early Bronze Age (Gaspari 2008). The remains of a Late Bronze Age dry land settlement known as Zalog I were found in the river Ljubija at the westernmost edge of the Ljubljansko barje basin (*Fig. 2.1*) (Gaspari 2006b).

Research, preventive archaeological excavations and topographic surveys also took place at the outskirts of the Ljubljansko barje. They revealed settlements on dry soil at the edge of the basin, such as at Jezero (Nadbath, Rutar, Žorž 2011; Žorž 2014) and Iška Loka (e.g. Velušček 2005a), and on the tops of dominant hills in the surroundings, such as Sveta Ana, Sveti Lovrenc, Pungrt, Gradišče near Bevke, Tičnica and elsewhere (*Fig. 2.1*) (e.g. Vuga 1980; Gaspari 2018). The scattered remains of the earliest pottery finds of the Resnikov prekop type from the isolated hill Breg near Škofljica, from the front edge of the gravel fan of the river Iška near the village of Ig (Turk & Vuga, 1982; Frelih 1986; Velušček 1997b) and from the settlements such as at Jezero[5] and Zamedvedica are also interesting (*Fig. 2.1*); the last site could be a pile-dwelling settlement. Deschmann, who discovered it, reported the remains of piles that were later never confirmed (Turk & Vuga 1984: 87).

2.2 CHRONOLOGY OF THE PILE-DWELLING SITES IN THE LJUBLJANSKO BARJE

From the very beginning of archaeology as a scientific discipline, a good chronology has been a prerequisite for understanding the palaeoenvironment, past events and people (e.g. Thomsen 1837; Montelius 1903). In the mid-1990s, the introduction of dendrochronology into the research of wetland archaeology in the Ljubljansko barje was a major and important step towards achieving this goal. Previously, the chronology published by Parzinger (1984) was widely accepted. This chronological framework proposed a division of the pile-dwelling settlements into seven horizons. A horizon was understood as the time span in which archaeological finds and settlements could be set. Furthermore, a chronological bridge between the middle Danube basin and northern Italy was proposed to support the dating efforts.

According to Parzinger, the first pile dwellings appeared during the LB I horizon (= Ljubljansko barje I), with representative pottery finds of the Resnikov prekop -a phase that corresponds with the Sopot-Lengyel III horizon in NW Croatia and also MBK IIb in Lower Austria and Burgenland. This was followed by LB II of the Epilengyel culture in north-eastern Austria, the Lasinja culture in south-eastern Austria, in Slovenia, in mainland Croatia and the western Danube basin in Hungary, documented with pottery finds designated as the Resnikov prekop -b and Bevke -a phase. The finds from the Resnikov prekop -c, Maharski prekop -a, Blatna Brezovica -a, Notranje Gorice -a and Veliko mostišče phases represent LB III with parallels in the Boleráz horizon in the Danube region. LB IV, documented in the Maharski prekop -b, Blatna Brezovica -b and Notranje Gorice -b phases, ran parallel to the developed Baden culture. It was followed by LB V correlated with Mako-Vučedol-Jevišovice B and described by the finds from the Notranje Gorice -c, Parte, Ig -a, Bevke -b and the Kamnik phase. The LB VI horizon, detected at Ig -b and Preserje, was defined by the finds of the Ljubljana culture. The chronological links with cultures such as the Vinkovci in Slavonia and Polada in northern Italy also seemed significant. The last horizon, of LB VII, was characterised by the Litzen pottery attributed to the Notranje Gorice -d and Ig -c phase.

Radiocarbon dating and later dendrochronology challenged this chronology (e.g. Bregant 1975; Forenbaher 1993; Velušček & Čufar 2003, 2014; Čufar, Velušček, Kromer 2013; Čufar et al. 2015). The LB I and II horizons were defined by the archaeological finds from the pile-dwelling settlement of Resnikov prekop, which Stojan Dimitrijević understood as a single-period settlement. He even used the pottery finds from Resnikov prekop to define the Lasinja culture. They were considered representative of his stage II-A, which also includes the pottery finds from Drulovka, Ptuj and most other sites with similar pottery from Slovenia (from Dimitrijević 1979a: 146).

Although this definition still appears in the scientific literature (e.g. Samonig 2003; Šavel, Karo 2012), it does not correspond to modern findings (e.g. cf. Budja 1983; Parzinger 1984; Velušček 2006b, 2011). This is quite evident in the case of Drulovka in Kranj. It is a prehistoric site first investigated by Korošec in the 1950s (e.g. Korošec 1960), which was followed by a significant excavation campaign in the 1980s (e.g. Valič 1988). It is a multi-period site with remains of a Neolithic, Eneolithic and Late Bronze/Early Iron Age settlement. Of these, the Neolithic and Eneolithic finds appear to be the most significant. Dimitrijević attributed them to a single phase (Dimitrijević 1979a: 146, 1979b: 361). Not long ago, they were divided into three different chronological and cultural phases (Guštin, Tomaž, Kavur 2005). According to the latter interpretation, the Drulovka I phase belongs to the newly proposed Sava group of the Lengyel culture, which chronologically precedes the Lasinja culture (see Guštin 2005). The Drulovka II phase is represented by finds from the Lasinja culture, and the last Neo-Eneolithic phase, Drulovka III, by finds from

[5] The earliest phase of a multi-period site (see Žorž 2014: 423).

Fig. 2.6: The Stare gmajne site with two distinct occupation zones. (Elaborated by Tamara Korošec; source © ARSO.)

the Furchenstich pottery culture. In absolute terms, this signifies the second quarter of the 5th millennium BC, while the two phases following Drulovka I should be placed in later periods around 4200 (Drulovka II) and even 3650 BC (Drulovka III).

What appears to be significant is that parallels for the pottery finds from the pile-dwelling settlement at Resnikov prekop come from the sites of the Sava group of the Lengyel culture (Turk & Svetličič 2005; Velušček 2006b). They can be related to the Drulovka I phase (Guštin, Tomaž, Kavur 2005). There are no finds of the Lasinja culture at Resnikov prekop[6], which is not surprising given that the results of the archaeological excavations do not contradict the hypothesis of a short-lived settlement that was never reoccupied (Čufar & Korenčič 2006; Velušček 2006b). Despite the differences, especially in the ornamental motifs (e.g. see Turk & Svetličič 2005: 72), it is fair to assume that the Resnikov prekop settlement belonged to the Sava group and not the developmental stage of the Lasinja culture, which is first attested later – during the 44th or 43rd centuries BC (e.g. Velušček 2006b: 58-63, 2011: 229-231; Balen 2008: 27-28; Sraka 2012: 359, Fig. 11; Kramberger 2021: 40; Horvat 2020: 20). Radiocarbon dating, which sets the settlement of Resnikov prekop roughly to the 46th century, supports this proposal (Dimitrijević 1979a: 179; Čufar & Korenčič 2006: 124)[7].

The Furchenstich pottery culture was defined in the Ljubljansko barje after the discoveries during the second half of the 1990s. Chronologically, it should be placed between the Parzinger horizons LB II and III. The culture was first documented in Hočevarica (Velušček 2004b), shortly afterwards in Gornje mostišče and Strojanova voda (Velušček & Čufar 2008) and then at the recently discovered sites of Črnelnik (Velušček et al. 2018) and Trebež. Dendrochronological analyses clearly assign them to the second quarter of the 4th millennium BC (Velušček et al. 2018; K. Čufar, personal communication).

Around 3500 BC, some decades after the last tree felling for the youngest pile-dwelling settlement of the Furchenstich pottery culture was documented, new settlements appeared. Although their pottery is in many ways similar to that of the previous culture, the obvious difference is in the decoration. Richly decorated vessels no longer occur. For several centuries, stab-and-drag incision disappears completely from the pottery. This readily recognisable feature can be explained with the arrival of newcomers from a different cultural or stylis-

[6] Bine Kramberger argues that some pottery vessels show features that link them to the Lasinja culture (e.g. Kramberger 2014: 339, 340, 373, 374).

[7] The radiocarbon dates published by Mlekuž et al. (2013: Tab. 1) suggest settlement activity at the Resnikov prekop site between the 6th and the second half of the 5th millennium BC, which has no support in material culture (cf. J. Korošec 1964; Harej 1975; Velušček 2006b).

tic background. The new settlers were also looking for entirely new sites on which to build their settlements. This seems revealing, because they clearly avoided the architectural remains of some dwellings abandoned not so long ago that were probably still present and visible (e.g. cf. K. F. Achino, in this monograph: Fig. 1.17). Dendrochronological research has recorded construction activities at pile-dwelling sites such as Maharski prekop, Črešnja pri Bistri and then at Spodnje mostišče and Stare gmajne, where the last phase of occupation[8] was dated towards the end of the 34th century BC (Čufar et al. 2015).

The Ljubljansko barje was repopulated in the 32nd century. Judging by the pottery, it was a continuity of development with the same cultural background, i.e. the Stare gmajne cultural group (Velušček 2009c). During this period the site of Stare gmajne was newely settled (*Figs. 2.6* and *2.10*). The new settlement was partially built on the location of the former village, with the main concentration of dwellings about 200 m further east towards the centre of the basin of the Ljubljansko barje (*Fig. 2.6*). On the other hand, new settlements were also established, such as Veliki Otavnik Ib (Gaspari et al. 2009) and Blatna Brezovica (Velušček 2009e). The latter, where dendrochronological analysis confirms building activities in the first half of the 31st century BC, marks the end of a period that can be correlated with Parzinger horizons III and IV (Parzinger 1984).

Archaeological research suggests there were no settlements in the Ljubljansko barje between the first half of the 31st century and the emergence of the local variant of the Vučedol culture in the 28th century (Velušček 2014). In any case, it is important to mention the alleged stone burial mound with scattered remains of two adults and a child at Žabji grad above the southern edge of the Ljubljansko barje (*Fig. 2.1*). Unfortunately, the data on this discovery are incomplete and the find itself is contradictory in many ways. The radiocarbon dating of the charcoal supposedly dates the stone burial mound to ca. 3000 BC (Nadbath, Rutar, Žorž 2011: 27).

Much more credible are the dates from the 28th century BC obtained by ^{14}C dating and the dendrochronological analyses of wood from the Parte-Iščica pile-dwelling site (Velušček, Čufar, Levanič 2000: 99, Table 1; Čufar, Velušček, Kromer 2013). The same period of human presence and activity in the area is confirmed by the radiocarbon dates of the horse bone from Založnica (Toškan 2018) and the dugout from the immediate vicinity of the pile-dwelling settlement at Veliki mah. Although the exact age of the latter site is still uncertain, the logboat has been ^{14}C dated to 4210 ± 40 uncal BP (2820-2660 cal BC) (Erič 2008: 14; Erič, Gaspari, Kavur 2012: 398), suggesting the same age for the settlement as well (Velušček 2020a).

Almost two decades ago, some building activities at the Založnica site were tentatively dated to the beginning of the 27th century according to the FRSP2 chronology (see Velušček & Čufar 2003; Čufar, Velušček, Kromer 2013). Davor Kržišnik has demonstrated in his master's thesis that the disputed chronology is consistent with other chronologies of the Ljubljansko barje around 2500 BC (Kržišnik 2014: Fig. 22). On the other hand, dendrochronologist Katarina Čufar considers this chronology peristently problematic in many aspects (K. Čufar, personal communication; cf. Leghissa 2021).

Be that as it may, the available data show we are not far from reality when claiming that the Ljubljansko barje was settled in the first half of the 3rd millennium, which would correspond to Parzinger horizon LB V. Stab-and-drag incisions reappear and then predominate on the fine pottery for a while. Typical Vučedol pottery forms and decorative motifs are among them. Influences or even imports from contemporaneous cultures such as the Globular Amphora, Corded Ware, Jevišovice and early Makó-Kosihy-Čaka phases are also very characteristic of this period, which continued until the 26th century, as Elena Leghissa (2017a: 276, 2021: 12, 29) argues. She calls the phenomenon the Ljubljansko barje variant of the Vučedol culture (e.g. see Leghissa 2021: 12-13).

During several research campaigns, building activities were much better documented at Parte, Založnica and Dušanovo, where many synchronized chronologies reveal that settlement began at the end of the 26th century and continued for half a century in Parte and until the end of the 25th century in Založnica (Velušček & Čufar 2003; Velušček, Toškan, Čufar 2011; Kržišnik 2014). The results of absolute dating and several previous studies (e.g. Dimitrijević 1979b; Harej 1987; Forenbaher 1993) clearly show we are dealing with the LB VI horizon of Parzinger (1984), which is otherwise known through the finds of the Ljubljana culture that supposedly dominated in the Ljubljansko barje during this period.

Surprisingly, research has provided an alternative interpretation. Many parallels for the pottery finds from Parte and Založnica[9] come from the Pannonian plain, from the sites of the Somogyvár-Vinkovci culture (cf. Kulcsár 2009). Consequently, both the Parte and Založnica sites were assigned to this post-Vučedol cultural phenomenon. Moreover, the chronological position of the Ljubljana culture was assessed as unclear and problematic (Velušček & Čufar 2003: 141).

To address this issue, there have been recent attempts to revive old hypotheses (e.g. Korošec & Korošec 1969; Dimitrijević 1979c; Parzinger 1984) according to which the Ljubljana culture represents the main post-Vučedol manifestation in the Ljubljansko barje (Leghissa

[8] Within the first or the earliest settlement at the site.

[9] The contemporaneous site of Dušanovo was discovered later in 2010 and yielded similar finds attributable to the same cultural context (Velušček, Toškan, Čufar 2011).

2017a; 2021). A proposal considers the two cultures (Ljubljana and Somogyvár-Vinkovci) to be contemporary. Moreover, at sites such as the 2nd Deschmann pile-dwelling settlement (Deschmann II; *Fig. 2.8*), where the pottery of the Ljubljana culture otherwise known for its rich decoration allegedly or apparently prevails, the modestly decorated pottery of the Somogyvár-Vinkovci culture is identified as common ware (or *Begleitkeramik* in German). Therefore, the culture of Somogyvár-Vinkovci seems to have played only a marginal role in the cultural development of the region. In fact, it was subordinate to the privileged Ljubljana culture in central Slovenia (compare with Leghissa 2017a: 284-285, 2021: 25).

Pottery finds attributed to the Ljubljana culture are attested at several sites such as Parte, Parte-Iščica, Založnica, Dušanovo (= Črni graben (e.g. see Velušček 2019: 73)) and Špica. According to Leghissa (2017a, 2021), the most numerous and most representative ceramic pieces of the Ljubljana culture are known from the 2nd Deschmann pile-dwelling settlement[10], which led her to seek its origin in the Ljubljansko barje, where she believes it developed at the end of the 26th and continued until the 25th century. She also assumes a limited eastward spread or influence of the Ljubljana culture. To the west, it reached the Karst, where it occurred in its original form, and possibly even northern Italy. Leghissa leaves open the question of the chronological and cultural relations with the somewhat different Adriatic variant that spread along the central-eastern Adriatic coast with its hinterland and on some islands, and considers the low ^{14}C dating of layers with the Ljubljana pottery from the caves Grapčeva špilja, on the island of Hvar, and the even more distant Odmut, in present-day Montenegro, to be problematic. For her, the material culture from important sites such as Mala gruda, Velika gruda and Boljevića gruda should be assigned to the Montenegro variant of the Vučedol culture or even Yamnaya culture and not to the Ljubljana culture or its Adriatic variant (Leghissa 2021: 11, 21, 28-30).

Stašo Forenbaher (2018) takes a fundamentally different approach. According to him, the Ljubljana-Adriatic style (or the Alpine and Adriatic variants of the Ljubljana culture (see Dimitrijević 1979c)) occurred along the eastern Adriatic coast with the islands and hinterland, from Lake Skadar in the south to the Trieste Karst and Ljubljansko barje in the north.

Using a model of independent phases, he sets the beginning of the style in the south between the calendar years 3337 and 3027 BC. The end should be sought in the north and thought with 68% probability to have occurred between 2525 and 2253 BC, which is also the approximate time frame for the emergence of the Cetina style. Following the t-model, i.e. successive phases, the transition of both styles from the Ljubljana-Adriatic to the Cetina style is 68% likely to have occurred between 2470 and 2324 BC. According to the ^{14}C data and the results of the dendrochronological investigations, the youngest manifestations of this phenomenon are found in the Ljubljansko barje and in north-eastern Istria (Pupićina peć). It can also not be overlooked that, in his opinion, the Ljubljana-Adriatic style occurs at least contemporaneously with the Classic and Late Vučedol phases and most probably precedes the Cetina style (Forenbaher 2018: 152, 153).

As far as the Ljubljansko barje is concerned, Forenbaher identifies very characteristic pottery of the Ljubljana-Adriatic style at the sites near Ig, where Deschmann conducted archaeological excavations in the 19th century, but less characteristic and also less numerous at the sites of Dušanovo, Črni graben, Parte, Parte-Iščica and Založnica (Forenbaher 2018: 152). When discussing the first appearance of this style in the region, he refers to some similar pottery sherds found at Parte-Iščica, which is chronologically attributed to the Vučedol culture (Velušček, Čufar, Levanič 2000; Forenbaher 2018). On the other hand, he argues that the proposed approximate age of ca. 2400 BC for the disappearance of the style is based on unreliable ^{14}C dates or contexts with the Ljubljana style ceramics in the Ljubljansko barje, which is also the case for the Pupićina peć site in north-eastern Istria and thus remains questionable.

Despite obvious genealogical differences, it is clear that both hypotheses, Forenbaher's conditionally (cf. Forenbaher 2018: 152), fix the occurrence of the Ljubljana culture in the Ljubljansko barje to the end of the 26th and throughout the 25th century BC. As already highlighted, according to Leghissa (2017a, 2021), the Ljubljana culture was contemporaneous with the Somogyvár-Vinkovci culture. The most convincing argument for this claim can be found in the presence of the pottery of both cultures on the same supposedly single-period sites (cf. Leghissa 2021: 23). While the pottery of the Ljubljana culture presumably dominates at the sites near Ig, it occurs only sporadically at Založnica and Dušanovo (see Velušček & Čufar 2003; Velušček, Toškan, Čufar 2011), where pottery with analogies in the Somogyvár-Vinkovci culture predominates (e.g. Leghissa 2021: 23).

Because the Somogyvár-Vinkovci culture represents a distant cultural phenomenon in the area of Ljubljansko barje (see Velušček & Čufar 2003; Kulcsár 2009). According to Leghissa (cf. Leghissa 2017a: 284, f.n. 1260), these sites/settlements could be either colonies of the promoters of the Somogyvár-Vinkovci style of pottery, or of actual foreigners or newcomers who apparently invaded the central area, the homeland, of the Ljubljana culture.

[10] About 100 years after the investigations at the 2nd Deschmann pile-dwelling settlement, some pottery finds were collected from Partovski kanal I (e.g. Harej 1974: Pls. 2: 4; 3: 7) that most probably belong to the same settlement, as researchers believe that the said drainage ditch cuts through the settlement in question (*Fig. 2.8*) (e.g. Harej 1974; Velušček 1997b).

In any case, these hypotheses do not offer a convincing explanation for the occurrence of the Somogyvár-Vinkovci culture pottery finds at sites where the pottery of the Ljubljana culture is at least apparently (cf. Leghissa 2017a, 2021) more common (e.g. the Deschmann's 2nd pile-dwelling settlement). It is not easy to accept the idea of common ware, or to imagine that there were two contemporary settlements inhabited by a population that favoured typical ceramics of the Somogyvár-Vinkovci culture, a dominant cultural expression in the Pannonian plain at that time (Kulcsár 2009), only 10 to 15 km from the presumed main settlement of the Ljubljana culture (cf. Leghissa 2021). With that in mind, the first question is what type of sites are we dealing with? Are these truly single-period sites, as Leghissa (2021: 23) argues, with ceramics from different cultural aspects, or multi-period sites, or something else that we do not yet fully understand?

In the search for answers to these questions, we will focus on the sites of Založnica, Dušanovo, Parte, Parte-Iščica, Špica and the 2nd Deschmann pile-dwelling settlement. Among other things, they share the pottery attributed to the cultures of Ljubljana and Somogyvár-Vinkovci. In addition, the typical Ljubljansko barje variant of the Vučedol culture pottery was also found at the 2nd Deschmann pile-dwelling settlement, Parte-Iščica, Parte and probably also Špica, as it is reported by Klasinc et al. (2010: 64).

The earliest site in this group appears to be Parte-Iščica, dated to the 28th and 27th centuries BC. As for the other sites, dendrochronological analyses and ^{14}C dating led scholars to largely agree they can be dated to the late 26th and 25th centuries BC, at least if excluding the elusive date of the problematic FRSP2 chronology from Založnica (see e.g. Leghissa 2021: 12-13, 26). To make things more complicated, the bone of a domesticated horse was also found at Založnica, which is currently the earliest find of its kind in Slovenia. The ^{14}C dating points to the 28th century BC (Toškan 2018 and B. Toškan, personal communication), which again supports the hypothesis of a possible earlier settlement phase at the site in question (cf. Velušček & Čufar 2003).

An interesting situation can also be observed at Dušanovo, where piles derive from two different zones of separate drainage ditches more than 140 metres apart and are dated in the years around 2500 BC. The dendrochronologically dated piles show traces of pruning for animal feeding (Kržišnik 2014). The analysis of the sample with the serial number DU -13-94 proves that pruning took place about 70 years before the tree was felled and used for the construction of the house dated to 2496 ± 18 BC. Two other pile samples, also dendrochronologically synchronized, prove a somewhat shorter period between the first recorded human contact with the trees and their felling.

Given the location of the Dušanovo settlement on the western shore of the lake, it can be assumed that the wood for its construction came from the surrounding area (see Čufar & Velušček 2012). Since there is no settlement in the vicinity[11] or at the Dušanovo site itself that would be several decades earlier than the one already identified, it is reasonable to assume that the documented human activities could be related to an as yet unknown earlier settlement phase datable before the mid-26th century BC (cf. Kržišnik 2014: 56). If it did really exist at the site of Dušanovo, it should predate for some decades the time when, as Leghissa (2021: 29) argues, the Ljubljana culture emerged in the Ljubljansko barje.

The Parte site, researched by Zorko Harej, is also very interesting (e.g. Harej 1987). All determined pottery belongs either to the Ljubljana culture (Harej 1978: Figs. 2: 1,2,4-12; 3; 4: 2, 12, 1981-1982: Figs. 10: 6,15; 11: 5; 15: 3,4,7, 1987: Figs. 1: 13,14; 9: 10,13, also see Leghissa 2017a: 281) or to the presumably contemporary, according to some scholars (e.g. Parzinger 1984; Leghissa 2021), Somogyvár-Vinkovci culture (Harej 1978: Figs. 4: 1; 5: 9; 6: 11; 7: 1,4; 9: 9, 1981-1982: Pls. 10: 3; 11: 1-4; 17: 1,2,17; 23: 1,6,9, 1987: Pls. 5: 9; 6: 6,9; 11:10, etc.), or even to the preceding Vučedol culture (Harej 1981-1982: Pls. 10: 11; 22: 1, 1987: Pl. 9: 7,11; cf. Leghissa 2021).

On the other hand, the dendrochronological analysis of the piles from Harej's excavation site revealed a dating to ca. 2500 to ca. 2450 BC. The time frame again falls in the period of the Ljubljana culture as Leghissa (e.g. 2021) defined, which makes the cultural affiliation of the finds at least surprising, if not unbelievable.

The extent of the Parte settlement/site is not known. The remains of supposedly another pile-dwelling site were discovered in the river Iščica, about 50 metres from Harej's excavations, known as the Parte-Iščica site (*Fig. 2.7*). The dendrochronological analyses of the piles found on the river bottom indicate more than one occupation phase between the first half of the 28th and the end of the 27th century (Čufar, Velušček, Kromer 2013). However, the extent of this site is also unknown. Bregant assumed that it extended into the right bank of the river Iščica, away from Harej's excavation site (Bregant 1964-1965: 180). On the contrary, more recent topographic surveys have shown that the site extends only on the left bank of the present riverbed towards the area that Harej researched at Parte (Velušček, Čufar, Levanič 2000; Leghissa 2021).

Even though a small number of pottery finds were recovered from the riverbed of Iščica (see P. Korošec 1964; Velušček, Čufar, Levanič 2000), they

[11] The nearest prehistoric settlement that could be dated to the first half of the 3rd millennium BC is Veliki mah. Its age has as yet not been confirmed, but the ^{14}C dating of the dugout canoe found nearby suggests it was the 28th century BC (Erič 2008; Erič, Gaspari, Kavur 2012; Velušček 2020a), which seems too early for the activity in question. Anyway, the site is located about 4 km from Dušanovo on the opposite side of the modern-day riverbed of the Ljubljanica (*Fig. 2.10*).

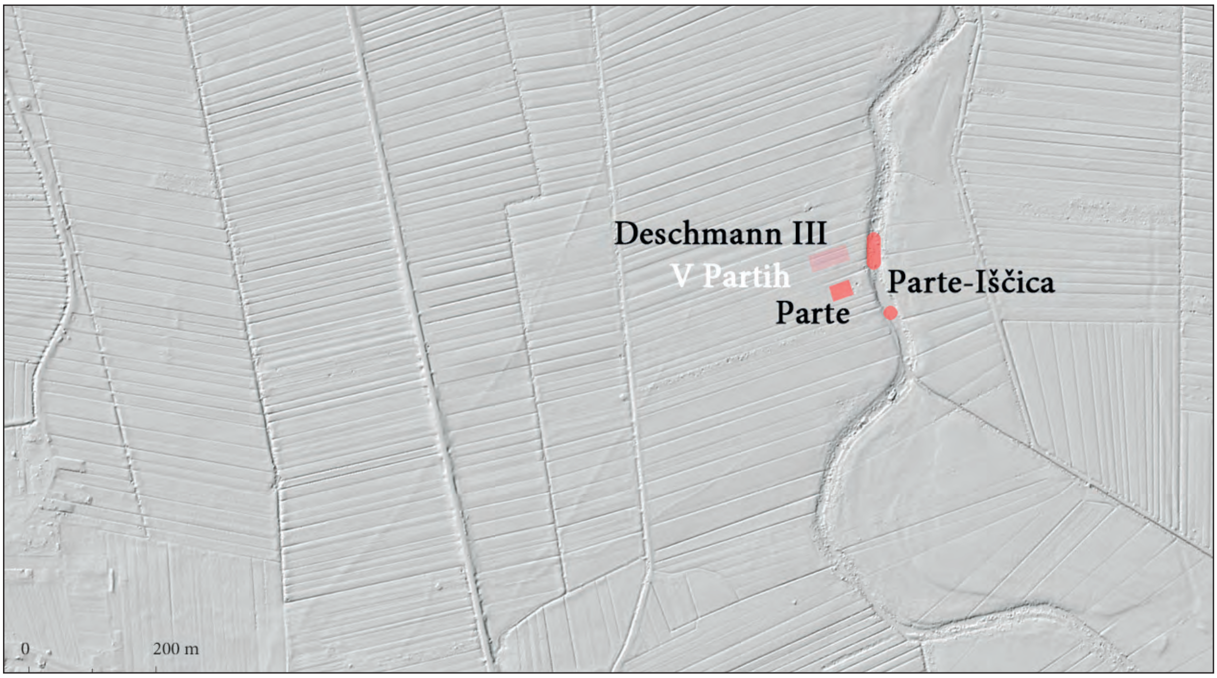

Fig. 2.7: The archaeological zone at V Partih. The positions of three archaeological sites are marked: presumed so called 3rd Deschmann pile-dwelling settlement (Deschmann III), Parte and Parte-Iščica (e.g. from Bregant 1964-1965; Harej 1987; Velušček 1997b; Velušček, Čufar, Levanič 2000; Leghissa 2021). (Elaborated by Tamara Korošec; source © ARSO.)

are considered culturally and chronologically heterogeneous and can be attributed to the cultures of Vučedol, Ljubljana, Somogyvár-Vinkovci, and even to the developed stage of the Early Bronze Age (Leghissa 2017a: 275, f.n. 1217, 2021: 23, 26). Among them, at least the Somogyvár-Vinkovci culture and the EBA pottery finds do not correspond with the estimated age of the documented settlement phase, which should be at least a century earlier (cf. Velušček & Čufar 2003; Kulcsár 2009; Čufar, Velušček, Kromer 2013; Leghissa 2021). An explanation for this discrepancy must be sought in erosion processes, even though a multi-period and multi-cultural nature of the site cannot be completely excluded (Velušček, Čufar, Levanič 2000; Leghissa 2021).

As for erosion, probably similar processes were observed at nearby Parte. Harej (e.g. 1978: 62) reports sand deposits, small branches, pieces of wood, leaves and so forth scattered in different stratigraphic units above and within the layer containing archaeological finds. Ceramic fragments of the same vessel were found in different grid squares over 10 m apart or even at different depths, half a metre or a metre apart (Harej 1978: 63, 1981-1982: 39, 41). There were also large differences in the thickness of the cultural layer between some of the squares. Consequently, the Parte site must be considered taphonomically very complex and thus stratigraphically (and probably also chronologically) problematic. A comparison with Maharski prekop and Resnikov prekop where erosion processes were detected thus seems appropriate (see Bregant 1975; Velušček 2006b, 2009a: 310; Achino, Toškan, Velušček 2017).

The Špica site also yielded a considerable number of pottery finds attributed to the Ljubljana culture (Klasinc et al. 2010; Leghissa 2021: 25), but also pottery similar to the Somogyvár-Vinkovci culture and allegedly Vučedol culture (Klasinc et al. 2010: 64; cf. Šinkovec 2012: 255-257; Leghissa 2017a: 284, f.n. 1257). Publications and preliminary reports suggest that the lake and, in particular, the hinterland streams and torrents strongly influenced the taphonomy of the site (e.g. Klasinc et al. 2010: 31, 34; Jančar 2016: 25-28; Andrič et al. 2017: 495); this would explain the highly fragmented and abraded Copper Age ceramic finds (Šinkovec 2012: 255).

Research has also shown that many layers from the pre-settlement period are missing, probably due to erosion processes. After the abandonment of the Late Copper Age[12] settlement, the situation calmed down, although the possibility of erosion cannot be completely excluded (Andrič et al. 2017: 495). Thus, it may not be surprising that artefacts such as bronze needles and two bronze daggers of the developed Bronze Age were found in the Copper Age cultural layer (Klasinc et al. 2010: 60, Tab. 10). The same can be said for two horse bones ^{14}C dated to the Late Bronze and Iron Ages (B. Toškan, personal communication).

[12] For the purposes of this monograph, the Somogyvár-Vinkovci culture and its horizon will be referred to as the Late Copper Age culture according to Velušček & Čufar (2003).

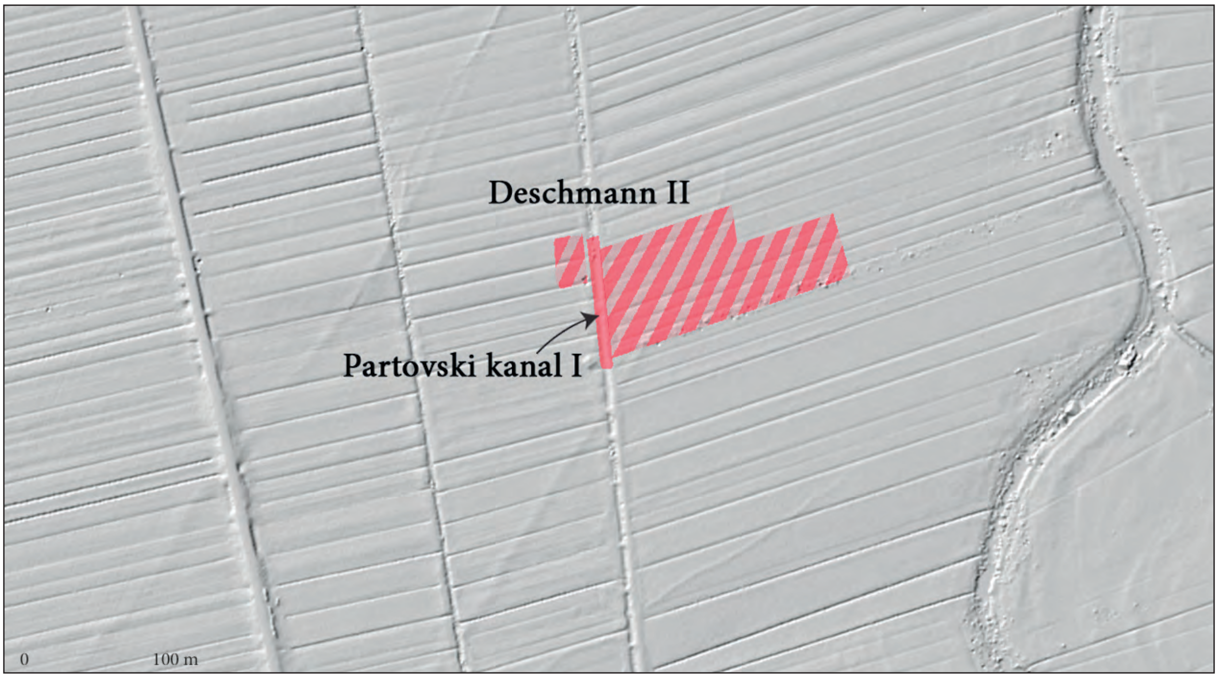

Fig. 2.8: The most probable location of the 2nd Deschmann pile-dwelling settlement (Deschmann II) and Partovski kanal I (e.g. from Bregant 1964-1965; Harej 1974; Velušček 1997a, 1997b; Leghissa 2021). (Elaborated by Tamara Korošec; source © ARSO.)

A sediment sample was also taken for luminescence dating, 30 cm below the cultural layer, and is estimated to be ca. 20,000 years old. In addition, 6 samples from the sediment column for pollen analysis were dated using the ^{14}C method. Two samples taken 15 cm above the cultural layer indicate the Iron Age. The ^{14}C-dated acorn was found in the layer below the two. At first, it was assigned to the cultural layer (Andrič et al. 2017: Figs. 4, 5), whereas the newest interpretation proposes it originated from the layer immediately below the cultural layer and probably arrived there during a flood that affected the site prior to the LCA settlement (Leghissa 2021: 26, f.n. 169). Thus we must bear in mind that the result of the acorn dating in the proposed new *in situ* position is very important for drawing conclusions about the taphonomy of the LCA settlement.

As Leghissa (2021: 26) argues, the date 4040 ± 40 uncal BP (2562 BC) (after Andrič et al. 2017: Fig. 4) should itself provide a *terminus post quem* for the LCA settlement and thus an additional argument for the absolute dating of the beginning of the Ljubljana culture (see Leghissa 2021: 28). And that is not all; the position of the acorn under the cultural layer allows a direct stratigraphic comparison with the deepest ^{14}C-dated sample of unidentified plant remains. Following their position, it can be assumed that both samples describe the last episodes of flooding events, which according to Andrič et al. (2017: 495) occurred one or more times in the Late Pleistocene and Early/Middle Holocene. In other words, according to Andrič et al., they must have occurred before the LCA settlement phase at the site. However, it is telling that the sample of an unidentified plant is at least several centuries later than the acorn. With a measured age of 3750 ± 40 uncal BP (2161 BC) (Andrič et al. 2017: Fig. 4), the unidentified plant was not even used for age-depth modelling because of possible disturbances in the sedimentation process[13].

The most famous pottery finds of the Ljubljana culture derive from the 2nd Deschmann pile-dwelling settlement (see Korošec & Korošec 1969; Leghissa 2017b). The site was excavated in 1876 and 1877 by Deschmann himself (*Fig. 2.8*) (e.g. cf. Velušček 1997a; Leghissa 2017a, 2021: Fig. 1). It was identified as the main pile-dwelling settlement (‘*der Hauptpfahlbau*’) (Deschmann 1878: 4). As special features, Deschmann mentions ‘cord impressions’ on the pottery vessels and items related to metallurgical activities (Deschamann 1876: 474-475, 478, 1878; also see Leghissa 2021: 12). In her dissertation, Leghissa (2017a, 2017b) has shown that the pottery and/or fragments with the handwritten dates 1876 and/or 1877 are mainly attributable to the 2nd Deschmann pile-dwelling settlement. Consequently, she also claims that all the pottery decorated with whipped-cord impressions was found there.

[13] Andrič et al. (2017: 495) seek to explain this discrepancy by younger roots or other plant material sinking into much older sediment.

The discussion on the pottery from this site must also take into account that Deschmann was mainly interested in the high-quality ceramics that looked good and were better preserved, the rest being thrown away. Certain amounts of pottery finds were also stolen during the excavation (Bregant 1964-1965: 180-181, 187; Leghissa 2017a, 2020), making it impossible to estimate the actual number of ceramic finds for each cultural group, and which remains can be attributed to the Ljubljana (Leghissa 2017b: Figs. 43: 1,3,4; 44: 2,4; 46: 7,8; 47: 1-3,5,6; 48: 1-3, etc.), the Vučedol (Leghissa 2017b: Figs. 8: 2,3; 11: 2; 16: 1; 40: 3; 62: 2,3, etc.) or the Somogyvár-Vinkovci cultures (Leghissa 2017b: Figs. 2: 1; 3: 1,3,6,7; 4: 7, etc.); this is a situation widely recognised by scholars.

In view of the above, it is (as yet) not possible to adequately solve the problem of the chronological position of the Ljubljana culture in the Ljubljansko barje, as Leghissa would have us believe (e.g. Leghissa 2021). The question that arises concerns the finds (artefacts!), which must predate the end of the 26th century, that define a presumably earlier phase at the Založnica and Dušanovo sites. Could they be attributed to the Ljubljana culture (see Velušček, Čufar 2003)? Not knowing the answer, it seems that for the time being proposals can only be based on a personal decision of each researcher on how to classify the finds of the Ljubljana culture (cf. Forenbaher 2018) – Leghissa (e.g. 2021) has done just that.

The chronological position of the Ljubljana culture that Leghissa proposes (e.g. 2021) raises many questions and does not offer conclusive evidence; a comprehensive study is needed that takes into account the horizontal stratigraphy and physiognomy of individual sites from the early and mid-3rd millennium in the Ljubljansko barje. All available ^{14}C dates must be evaluated according to the same criteria, as should the results of dendrochronological investigations. New fieldwork will probably be needed to clarify some issues and, finally, the theories of the 3rd millennium BC must be reconsidered and placed in a wider European context.

The Zaloke and Konec sites, east and west of Bevke (*Figs. 2.1* and 2.*10*) (Črešnar 2011, 2014; Dirjec 1991; Velušček 1997b), shed light on the second half of the 3rd millennium. Excavations there unearthed several piles and a large quantity of typical Early Bronze Age pottery. The ^{14}C dates support the dating of human presence at the sites in the final centuries of the 3rd millennium.

There is more data for the first half of the 2nd millennium, i.e. the horizon of LB VII according to Parzinger (1984). The greatest quantity of finds come from Mali Otavnik (*Fig. 2.10*). The site in the riverbed of the Bistra has been interpreted as a settlement, more precisely a pile-dwelling settlement (Gaspari 2008; Velušček 2008). The characteristic pottery with Litzen decoration dates it to the Early Bronze Age, specifically to the early and developed horizon of the Litzen pottery of the Early Bronze Age A1 phase and the transition to A2. The ^{14}C analysis of the animal bone sample offer a date of 3560 ± 40 uncal BP (2020-1770 BC), which the author of that publication deems probably contaminated and too late (Gaspari 2008: 61, f.n. 5); this calls for caution in the interpretation.

The metal finds from this period are also interesting. A Late Early Bronze Age dagger came to light in the second year of Deschmann's excavations in the area of the pile dwellings from the middle or even first half of the 3rd millennium at Ig, where fragments of EBA Litzen pottery were also found (Gabrovec 1983: 31-34). Other metal finds are more likely to be chance (e.g. Gabrovec 1983: 32; Potočnik 1988-1989; Pavlin 2006; Turk et al. 2009) or often water finds. The latter are mainly interpreted as cult finds (Turk et al. 2009), which is possible but cannot be generalized (cf. Velušček & Čufar 2014: 61).

In recent decades, remains of prehistoric settlements from the Middle Copper Age or later periods have been found along the river Bistra, as well as the Ljubljanica in the wider area of the confluence with the Bistra (see Gaspari 2008; Gaspari et al. 2009; Velušček 2019). One of these is located at Blato, a site discovered in 2010 (*Fig. 2.10*). The remains of piles and pottery found on the cornfield, dating to the second half of the 2nd millennium BC, suggest it was a pile-dwelling settlement (Velušček, Toškan, Čufar 2011). If this was indeed the case, the location at the centre of the wetland basin indicates it was most likely located ashore near the edge of a receding lake. During this period and especially in later centuries, the settlement of the Ljubljansko barje concentrated on the dry fringes (e.g. Iška Loka) or the surrounding hills (e.g. Tičnica, Sveta Ana, Sveti Lovrenc, Pungrt).

2.3 A CASE STUDY: PILE-DWELLING SETTLEMENTS IN THE LJUBLJANSKO BARJE

The last three decades of wetland research in the Ljubljansko barje have been marked by the activities of the Department of Archaeology at the University of Ljubljana and even more so the Institute of Archaeology ZRC SAZU.

The former research group drew attention by almost denying the presence of pile dwellings in the area in question or only dating them towards the end of the period traditionally referred to as the pile-dwelling period. The results of the archaeological research at Resnikov prekop and Maharski prekop and the area in between have been interpreted in a partially contradictory manner (Budja 1994; Budja & Mlekuž 2008a, 2008b with references). A heated debate developed, but lost momentum after the publication of the results of the

2002 excavation campaign at Resnikov prekop (Velušček 2006a, 2013 with references). It turned out that the site had been naturally destroyed in late prehistory. The original settlement layer was eroded and the vertical stratigraphy could therefore not serve as evidence for the hypothesis of a settlement on dry soil near a river (Budja 1994; also see Bregant 1964: 23). Furthermore, the remains of piles indicate a pile-dwelling settlement at Resnikov prekop. Since they are not present in large numbers, it can be concluded that the settlement was short-lived and little or almost nothing was repaired or rebuilt on this spot (Bregant 1964: 22; Velušček 2006b; Achino, Toškan, Velušček 2017). The site has never been repopulated. In Roman times, a road led over the exposed remains of the prehistoric site. In addition to the prehistoric finds, objects from the Roman period were also unearthed during the investigations in 1962 and 2002. They all came from a single layer with prehistoric remains above the lake marl (see Korošec 1964a; Velušček 2006b).

Comparable erosion processes can still be observed today. About 700 metres and a good kilometre north of Resnikov prekop, the river Iščica eroded the cultural layer of two sites with pile-dwelling settlements such as Spodnje mostišče from the 4th and Parte-Iščica from the 3rd millennium (*Figs. 2.3* and 2.*7*) (Velušček 2015). The same applies to Veliki Otavnik Ib (*Fig. 2.10*), which is partly situated in the riverbed of the Bistra (Gaspari et al. 2009). The consequences of erosion processes have also been observed at Špica (Klasinc et al. 2010: 30) and Maharski prekop (e.g. Bregant 1975), possibly also Parte (e.g. Harej 1978). Erosion processes in the Ljubljansko barje, influenced by water flows from the periphery and hinterland, thus make the investigation of past events and the palaeoenvironment very difficult. It seems that we have paid too little attention to this problem in our interpretations so far (cf. Gaspari 2006a).

The Institute of Archaeology ZRC SAZU conducted small-scale interdisciplinary research at Stare gmajne, Blatna Brezovica and Hočevarica (*Fig. 2.10*). These sites have provided a lot of information about the environment in which the pile dwellings were built (e.g. Velušček 2009b; Andrič 2020). They show that the settlements stood on wet soil, probably not far from the inflow of a still unknown watercourse into the lake (Turk & Horvat 2009a, 2009b; Turk & Velušček 2013). The obvious proximity of the settlement to water – river or lake – is confirmed by finds such as two dugouts from Stare gmajne, which, together with a cart date to the 32nd century BC (see Velušček, Čufar, Zupančič 2009).

A lake environment can also be inferred from the remains of birds and fish (e.g. Govedič 2004; Janžekovič & Malez 2004; Velušček et al. 2004; Janžekovič et al. 2021). However, the settlement at Stare gmajne was not erected on open water, but in a wetland, marsh or swamp, as the finds of sheep and dog coprolites from both parts of the site clearly show (Tolar et al. 2021). In addition, alder stumps were found in the cultural layer of Trench 2 from 2006, only a few metres from the famous wooden wheel with an axle. Their stratigraphic positions confirm that alder trees grew and were felled during the formation of the anthropogenic layer, in other words during the occupation of the site (Velušček 2009d).

The most convincing argument for the existence of the 'lake of the pile-dwellers', as the famous Slovenian geographer Anton Melik called it (Melik 1946), are the locations of the chronologically arranged pile-dwelling sites. Assuming that the prehistoric villages were located on the shore of the lake (e.g. Velušček & Čufar 2008; Turk & Velušček 2013)[14], a pattern was first described in the south-eastern part of the Ljubljansko barje (*Fig. 2.9*). The earliest remains of a prehistoric stilt settlement were found at its southernmost point. For the subsequent villages, sites were chosen to the north, towards the centre of the modern-day wetland. It looks like they followed the shoreline of the receding lake, as Ložar already suggested (cf. Ložar 1942). The last settlements, dated to the middle of the 3rd or even the 2nd millennium, are more than a kilometre further north than those dated to the 5th millennium BC. The intermediate area holds settlement sites dating back to the 4th millennium.

It is also striking that all prehistoric settlements are located almost parallel to the modern-day front edge of the gravel fan of the river Iška in a distance between 500 and 1200 metres. A reasonable explanation can be found in their economy, which included agriculture (e.g. Velušček, Čufar 2014), for which a gravel fan is very suitable (Tancik 1965; Prus 2008).

Pile-dwelling sites also came to light in the natural bay south of the central part of the Ljubljansko barje. Following the model of a retreating lake, the pile-dwellers of the first half of the 4th millennium chose a spot on the edge, while those in the 3rd millennium used the central zone of the bay further north for their settlement (*Fig. 2.5*).

A very similar picture is in the western Ljubljansko barje. Although the distribution of the pile-dwelling settlements of the 4th millennium seems confusing here, the settlements of the 3rd and 2nd millennia show a pattern (*Fig. 2.10*)[15]. And here, too, it is repeated at the

[14] Deschmann discovered a large number of completely preserved ceramic vessels (e.g. Leghissa 2021), which is not comparable to the situation on all other pile dwellings in Ljubljansko barje including Notranje Gorice investigated before World War I (Schmid 1910: Figs. 5-7). According to some interpretations, this could indicate the existence of real pile dwellings on open water (e.g. Perini 1980: 31, 1994: 258; Bellintani, Silvestri, Franzoi 2014: 69). Leghissa, however, suggests a sudden abandonment of the settlements as an alternative explanation (Leghissa 2017a: 276, f.n. 1223).

[15] The settlement at Mali Otavnik from the early 2nd millennium BC stands out in its age and location in the Ljubljansko barje. It lies in the immediate vicinity of the pile-dwelling

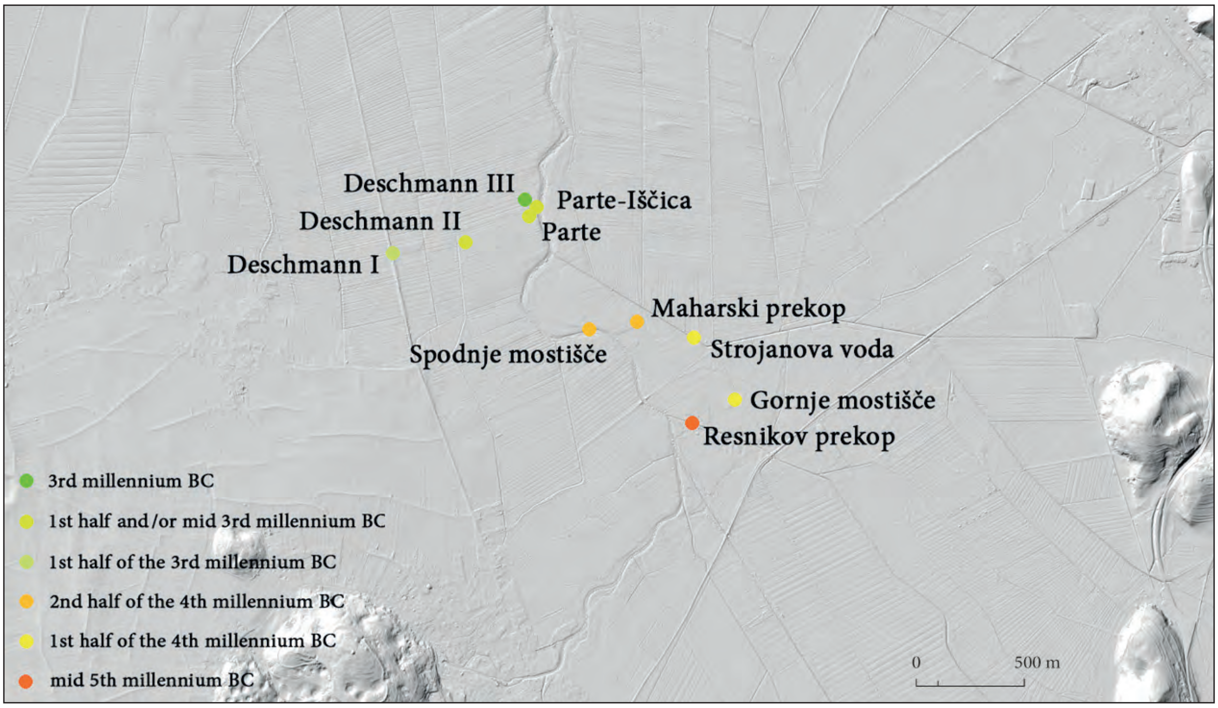

Fig. 2.9: The archaeological zone north and north-east of the village of Ig with wetland sites arranged chronologically. (Elaborated by Tamara Korošec; source © ARSO.)

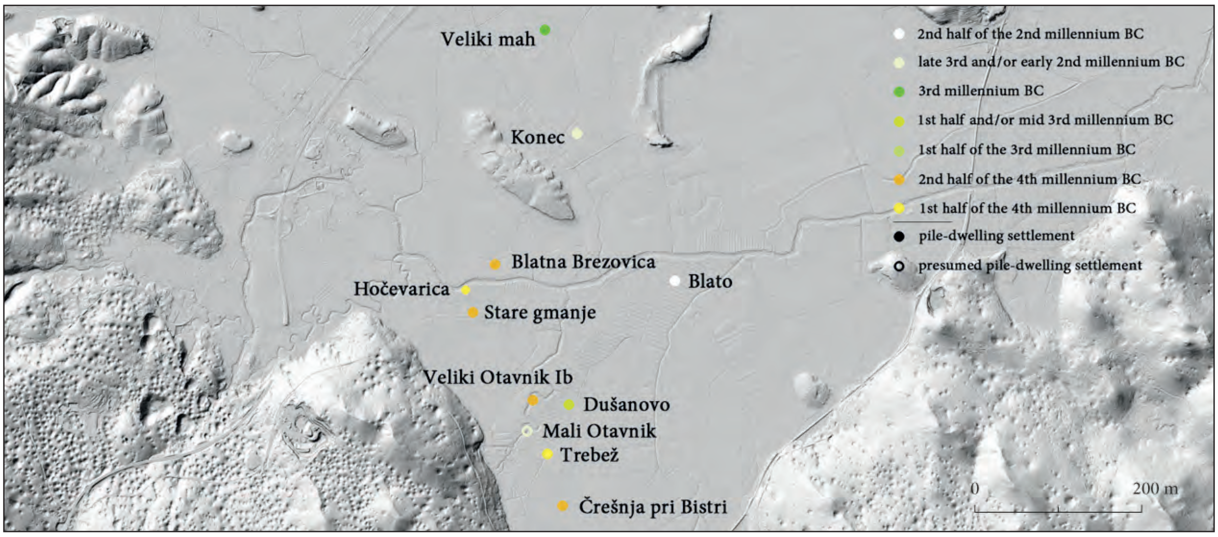

Fig. 2.10: Western part of the Ljubljansko barje with marked locations of pile-dwelling settlements from different periods. (Elaborated by Tamara Korošec; source © ARSO.)

level of individual sites. At Stare gmajne, for example, a concentration of prehistoric dwellings was found on two different locations. The western part of the settlement is mostly dated to the 34th century, while during the 32nd century the settlement centre shifted about 150 to 300 metres to the east, towards the centre of the Ljubljansko barje (*Fig. 2.6*) (Velušček 2009c, 2009d; Čufar et al. 2009).

settlement from the 4th millennium and in the hinterland of the pile-dwellings from the 4th and the mid-3rd millennium (*Fig. 2.10*). A possible explanation for the peculiar location of the site could be in its typology that may not be a pile-dwelling settlement at all (Velušček 2019).

2.3.1 STILT HOUSES?

The question of whether one can speak of houses on stilts in the Ljubljansko barje or whether they were dwellings with the floor on wet ground has a long and lively history in Slovenia, especially in the works of Ložar (1941b; 1942), Korošec (1955), Bregant (1964: 18-19) and Budja (1994). Both interpretations can be found in the literature, but it seems that the pile dwellings have been more popular (see Korošec 1955; Bregant 1964; Velušček 2020b). In fact, it is a view present in the scientific discourse since the beginnings of the pile-dwelling research, when the first discoveries of piles and associated prehistoric finds were interpreted as the remains of dwellings with elevated floors built on wooden platforms (e.g. Keller 1854; Deschmann 1875, 1876). Even today, this seems to be a pragmatic interpretation. However, the interpretation of a settlement on stilts relies on a minimum of material evidence, i.e. mainly the existence of load-bearing piles, with some exceptions related to the environmental conditions and thus state of preservation. As it has been stated many times, the interpretation should not be simplified.

The predominant wood species recorded at such sites are ash and occassionally oak. Other woods such as beech, poplar, hornbeam, willow, maple, elm and hazel are less present and they seem not to have been so popular among the pile-dwellers for the load-bearing elements of their houses. An exception is the site at Resnikov prekop with a clear prevalence of alder piles, followed by ash (e.g. Šercelj 1981-1982; Čufar & Velušček 2012: 53).

The tops of the piles (heads) usually come to light just above other archaeological remains (see also Korošec 1963: 21). In the cases of Hočevarica and Stare gmajne, the preservation of the heads is usually related to the level of groundwater that prevents the decay of organic matter. In addition, there are strong fluctuations of groundwater level at Stare gmajne, which severely endangered the pile heads; traces of decay and desiccation are clearly visible (*Fig. 2.11*). The situation is even worse where groundwater level lies too deep or where, for example, its fluctuations are more pronounced and especially where the periods between dry and wet phases are longer. There, the process of decay is greatly accelerated. Good examples are the sites of Blatna Brezovica, on the canal bank of Lipovski kanal, where the wood survived so dried out that it is completely unsuitable for dendrochronological analysis (Velušček 2009e), and at Špica, where the already decayed piles in some places on the bank of the Ljubljanica river can only be recognised as dark circular patches in the soil (Klasinc et al. 2010: Fig. 8; Šinkovec 2012; Jančar 2016).

The pile heads are sometimes found within a cultural layer, although their position and size indicate that they were constructional elements of a prehistoric dwelling (e.g. Špica (Jančar 2016)). At Maharski prekop, they were found at different levels (Bregant 1974a, 1974b, 1975). Since two main groups have been identified, some authors assume two phases of habitation covering more than eight hundred years (Mlekuž et al. 2012). According to Mlekuž et al. (2012), the lower piles belong to the early phase. Although this cannot be excluded in all cases, they should be interpreted with caution, as I have shown (see Velušček 2013).

Different levels of stilt heads have also been documented at the Parte site (e.g. Harej 1987: 142, Appendix 1). Similarly, they vary by about 60 cm at Stare gmajne. The piles found in the river Bistra at Veliki Otavnik Ib clearly indicate erosion processes in their transformation. Shorter and lower pile heads can be found in the middle of the riverbed, others are preserved much higher on the bank slopes (Gaspari et al. 2009: Fig. 6.5).

In Stare gmajne, the heads of the piles without traces of woodworking or subsequent reshaping predominate. Deschmann observed a similar situation at his first pile-dwelling settlement (Deschmann 1875: 276). Photographs show that a similar assumption can be made for Blatna Brezovica (cf. Korošec 1963: 12, Pls. 2-7: 1, Appendices IV, VI, VII), Maharski prekop (cf. Bregant 1974a, 1974b, 1975) and also Špica, where stilts appear “at the level of the cultural layers” (Klasinc et al. 2010: 49).

Fig. 2.11: Dried-up pile heads in the test trench at Stare gmajne of the 2007 research campaign. (Photo: Dejan Veranič.)

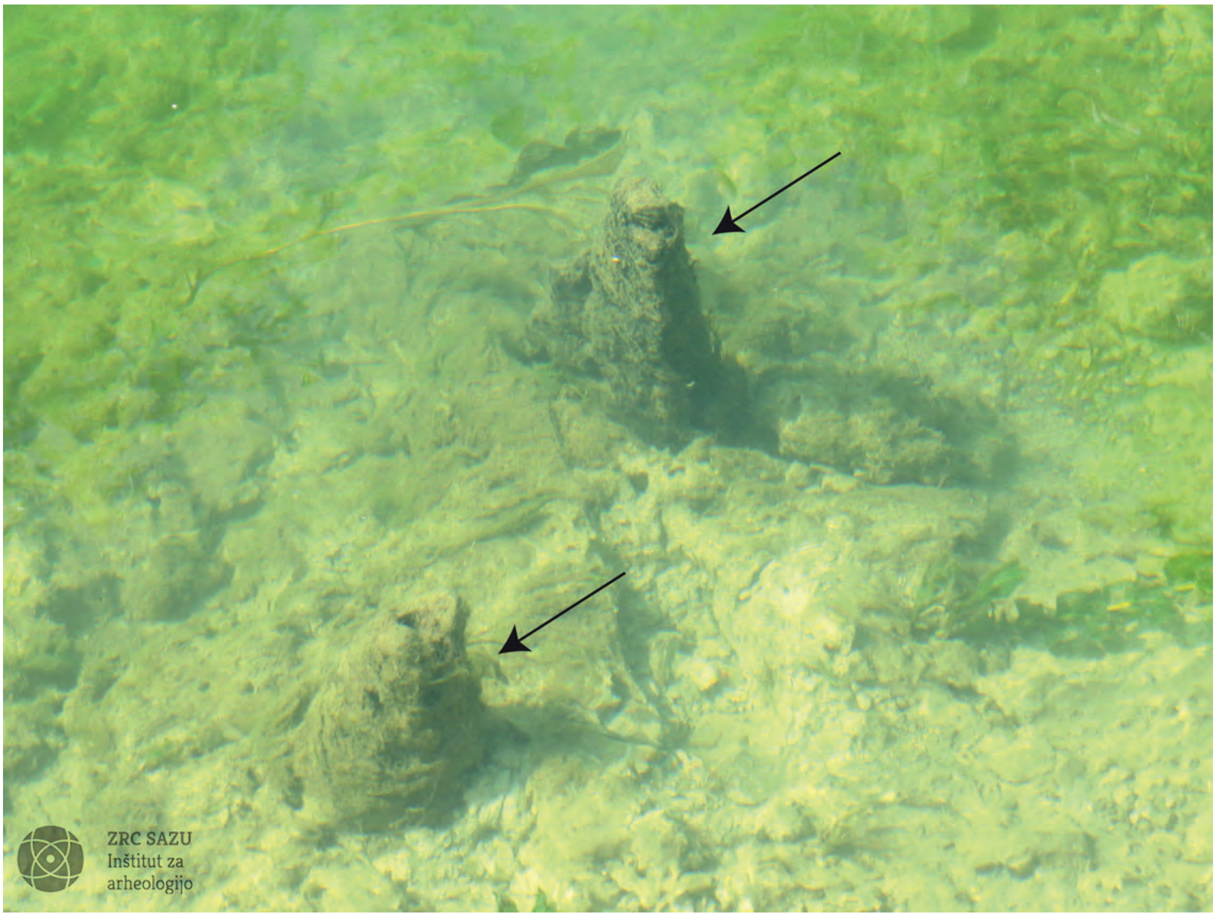

Fig. 2.12: The conical ends of the pile heads in the right bank of the Iščica river, at the Spodnje mostišče site, are the result of erosion processes. Fig. elaborated by Tamara Korošec. (Photo: Anton Velušček, 2014.)

At Resnikov prekop, piles appeared only 10 cm above the layer of lake marl. Something similar was documented during excavations in 1957 (Harej 1975: 146-147) and 2002 (Velušček 2006b: Fig. 5). Most of the piles were more or less horizontally broken, including some with sharpened heads. Tatjana Bregant ruled out an anthropogenic origin for such head form. According to her, they would have to have been gnawed on by beavers (Bregant 1964: 10), which seems unlikely given the behaviour of today's Eurasian beaver (Kryštufek 1991). In contrast, the pile heads at the Parte site were also mostly sharpened (e.g. Harej 1978: 76, Pl. 12: 2,7, 1981-1982: 98). Heads with a length of 10 to 15 cm predominate, while the sharpened end on the thicker stilts reaches a length of more than 20 cm. Zorko Harej suspects that they were of anthropogenic origin and supported a heavy habitation platform (e.g. Harej 1978: 76). The lack of data prevents us from evaluating his opinion, though pile sharpening elsewhere appears to have been a natural process caused by water erosion. At Spodnje mostišče with piles from ca. 3400 BC, this process can be observed on the bottom of the Iščica river, where the upper level of the lake sediment deposited before the cultural layer was already eroded. As a result, heavy artefacts, bones and stones are scattered in the marl and trapped between the piles (cf. Achino, Toškan, Velušček 2017). Where the piles protruded from the bottom, they were abraded and sharpened (*Fig. 2.12*). This process is ongoing. Another example of a naturally sharpened pile head protruding from the bottom of the river Bistra at Veliki Otavnik Ib, on the opposite side of the Ljubljansko barje, has been photographically documented (see Gaspari et al. 2009: Fig. 6: 4).

There is much less data about the depth the sharpened pile tips reached, although Deschmann was the first to report about them (Deschmann 1875: 276; also see Ložar 1942: 85). For the pile dwellings near Ig, he recorded that the piles were driven 4 to 5 feet[16] deep into the mud (lake marl). At Maharski prekop, the piles were driven up to 2 m deep into the marl (e.g. Bregant 1974a: 12), with some preserved over 4 m in length and reaching more than 3 m into the marl (see Bregant 1974a: no. 17, 1974b: no. 33). At the Parte site, four piles

16 Approximately between 1.2 and 1.6 metres in the metric system.

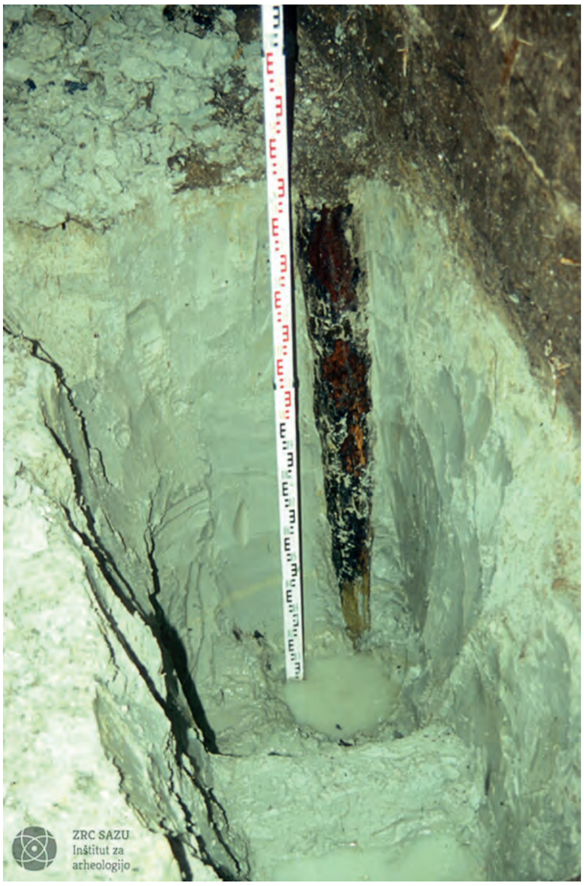

Fig. 2.13: The complete excavated pile from the Resnikov prekop site reached a depth of 1.6 metres relative to the highest level of the former lake sediment. (Photo: Anton Velušček.)

with partly worked tips were fully excavated. They were driven 90 to 165 centimetres deep into the former lake sediment (Harej 1978: 64). A case documented in 2002 at Resnikov prekop shows that the sole wholly excavated pile was driven into the marl to a depth of about 160 centimetres (*Fig. 2.13*). Forty years earlier, piles were found that were driven obliquely between 0.25 and 1 m deep in the lake sediment and those that were inserted to a depth of about 2 m (Bregant 1964: 21, Appendix 4). At Notranje Gorice, Schmid reported about two piles which reached a depth of 1.63 m and 2.56 m (Schmid 1910: 93a). While during the research of Harej most of the piles were driven about 1.35 m deep into the lake sediment (Harej 1975: 147). At Špica, 534 of the 2541 piles were completely excavated, of which only 24 did not have sharpened tips. Based on some photos and profile drawings, it can be assumed that most of them were driven deeper than 0.5 m into the marl (Klasinc et al. 2010: 49, Appendices 6, 7; Šinkovec 2012: Figs. 3, 5).

There are also huge differences between sites in the density of the piles used for the understructure of prehistoric buildings. The site of Špica is an example with densely distributed piles. They are interpreted as the supporting structure of rectangular houses, both with and without a raised floor (e.g. Šinkovec, Zupanc 2011), as can be seen most clearly, for example, in Trench 1004 (Jančar 2016). Comparable examples, albeit of a pile density seemingly lower probably due to inaccurately drawn excavation plans, can be found on the Peruzzi plan of the 1st Deschmann pile-dwelling settlement drawn in 1875 (Vuga 1989) and on the plan of the pile-dwelling settlement at Notranje Gorice from 1907 and 1908 (*Fig. 2.2*) (Harej 1976: 89). Deschmann mentions densely arranged, round timber piles for the pile-dwelling settlement at Ig, which was excavated in his second and third year of research (Deschmann 1878: 4; Leghissa 2021: 12). Densely arranged piles are also attested at the Parte-Iščica site in today's Iščica riverbed (Velušček, Čufar, Levanič 2000: Fig. 8).

The situation is different at other sites where the density of stilts seems to be much lower, such as Blatna Brezovica, Maharski prekop, Parte and Spodnje mostišče (Čufar, Levanič, Velušček 1998: Fig. 10; Korošec 1963: Appendix X). They are arranged in clearly visible parallel rows. There are mostly three rows per house, as documented at Parte (*Fig. 2.19*) and Maharski prekop (e.g. *Fig. 2.22*) (Velušček 2001, Fig. 23; cf. Bregant 1996). The settlement at Maharski prekop was partially surrounded by a double palisade of timbers (*Fig. 2.14*). Otherwise, the piles, on average 8 to 11 cm thick, were mainly ar-

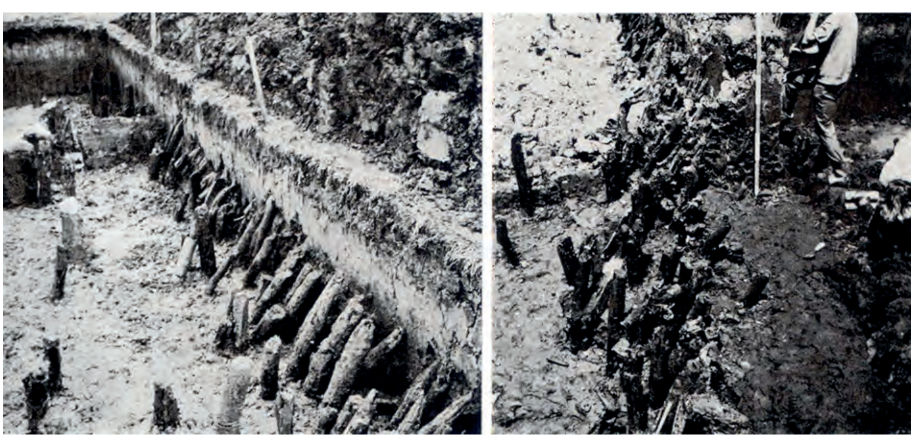

Fig. 2.14: A palisade composed of timbers in two rows was found in the pile-dwelling settlement at Maharski prekop (from Bregant 1974a: Pl. 1: 4,5).

ranged in straight, parallel rows. They can also occur in smaller groups. Some rows overlap, possibly as the result of several habitation phases at a site or the insertion of additional piles during individual habitation phases (cf. Velušček, Čufar, Levanič 2000).

As already mentioned, there is a dense network of piles at Part-Iščica. A large number of them indicate intensive building activity, e.g. repairs or construction of new dwellings (foundation of a new village), which almost overlapped the ground plans of the previous houses (*Figs. 2.15* and *2.21*). And, importantly, all these processes took place over a short period of time, certainly not more than two centuries. The dendrochronological investigations identified two chronologically separate settlements or building phases at the site (cf. Velušček, Čufar, Levanič 2000: 89). The first habitation phase according to the PI-FRSP2 and PI-FASY1 chronologies (houses E1-E4) seems to date to the 28th and/or early 27th century, the next phase according to the PI-FRSP1 chronology (house B1) most likely to the second half of the 27th century (Čufar, Velušček, Kromer 2013).

At the Parte-Iščica site, the ground plans of rectangular house substructures were dendrochronologically identified for the first time in the Ljubljansko barje (Velušček, Čufar, Levanič 2000). The three contemporary houses (E1 to E3) seem to have been intentionally arranged parallel to each other (*Fig. 2.16*).

This reinterpretation was of great importance for the discussion about the type of dwellings and settlements in the Ljubljansko barje. As a result, a new reconstruction of the prehistoric village at Maharski prekop was proposed, which differs significantly from Tatjana Bregant's architectural model made for an exhibition in 1996 (*Figs. 2.17* and *2.18*). So far, the rectangular and detached houses have been documented also at Parte (*Fig. 2.19*), Dušanovo[17] (*Fig. 2.20*) and Špica (see Jančar 2016).

The predominant ground plan of the rectangular houses consisted of three straight and parallel rows. The roughly contemporary house models from different parts of Europe (e.g. Garašanin 1979: 113, Fig. 10: 11, Pl. 16: 7) and climatic conditions at the southern Alpine foothills (e.g. Andrič 2009; Groneborn 2009) suggest that the middle row supported the midline of the house with the roof ridge, while the lateral rows represented

[17] The discussed part of the Dušanovo site was initially published as a separate site and called Črni graben (Velušček, Toškan, Čufar 2011; cf. Velušček 2019).

Fig. 2.15: Parte-Iščica site in a river bed of Iščica with a group of piles of different chronological phases (after Velušček, Čufar, Levanič 2000: Fig. 8: left). (Drawing by Tamara Korošec.)

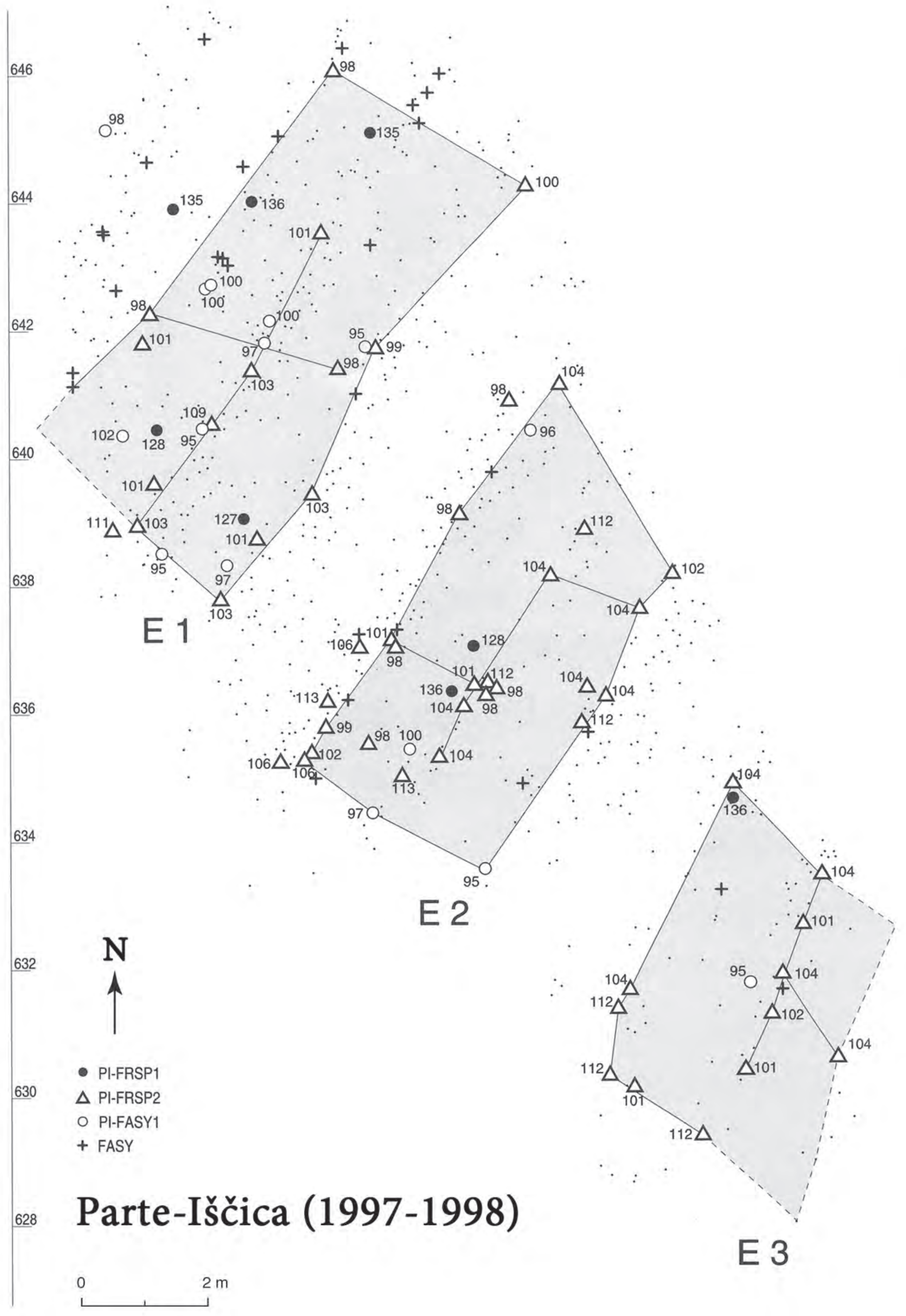

Fig. 2.16: Parte-Iščica: three rectangular ground plans of contemporary houses were discovered after dendrochronological analysis (after Velušček, Čufar, Levanič 2000: Fig. 6). (Drawing by Tamara Korošec.)

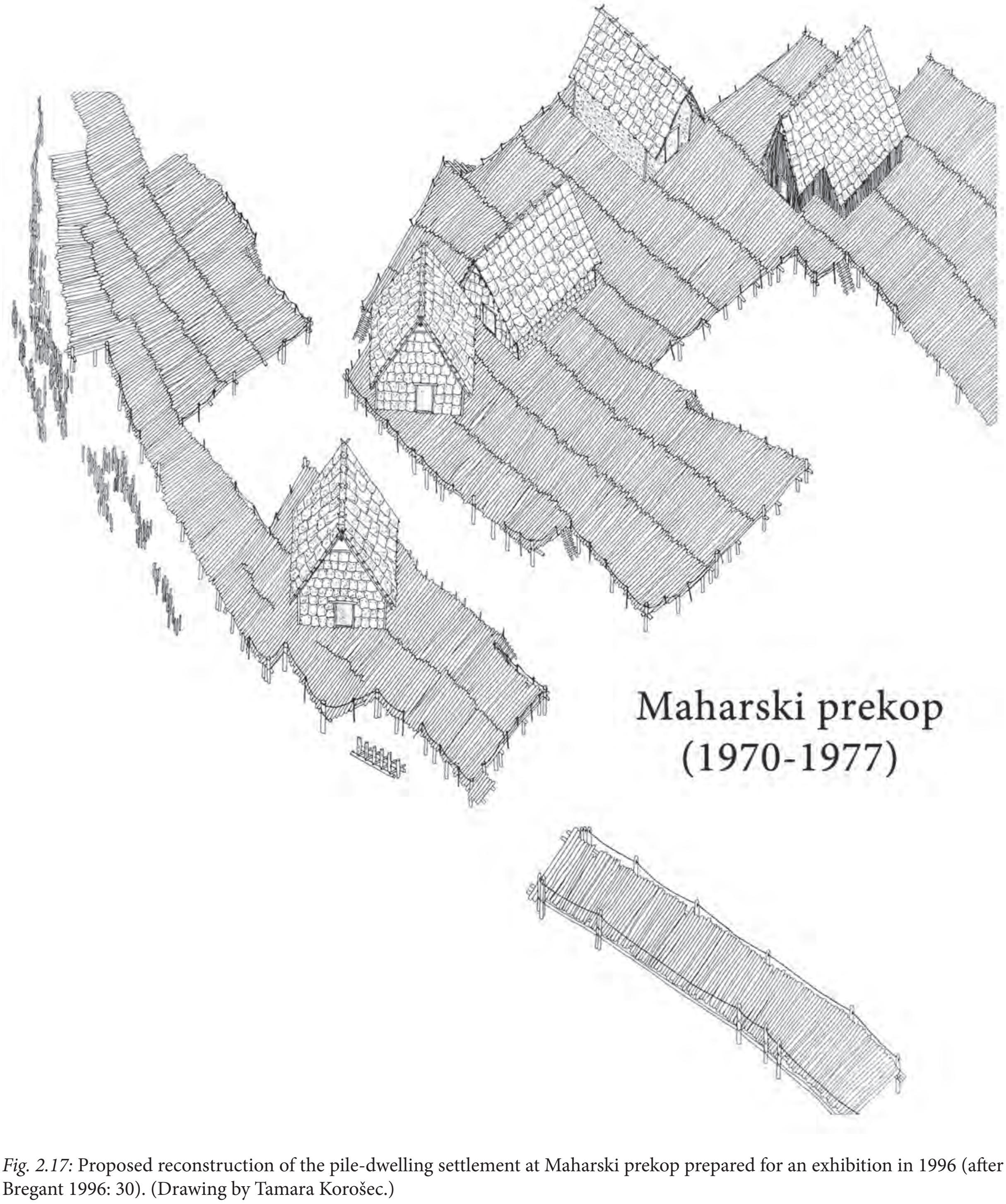

Fig. 2.17: Proposed reconstruction of the pile-dwelling settlement at Maharski prekop prepared for an exhibition in 1996 (after Bregant 1996: 30). (Drawing by Tamara Korošec.)

(or supported) the outer walls. We can infer from the predominant distance of about 1.5 m between them, as is the case at Maharski prekop from the mid-4th millennium (*Fig. 2.22*), as well as the houses of the Parte-Iščica (*Fig. 2.16*) and Parte (excavation campaign in 1981) (*Fig. 2.19*) pile-dwelling settlements from the 3rd millennium, that these substructures supported a raised floor. If the middle row were in the function of a wall, the buildings would have been divided into long, rather narrow and functionless spaces (e.g. cf. Koeninger 2006: 80-87), which contradicts the knowledge and adaptability that the pile-dwellers had in their everyday life in the 4th millennium BC[18] (e.g. cf. Velušček 2004b, 2009b).

[18] E.g. the discovery of yarn, technically advanced prehistoric cart, metallurgy, intentional use of wood for different purposes (e.g. Tolar, Čufar, Velušček 2008; Velušček 2008;

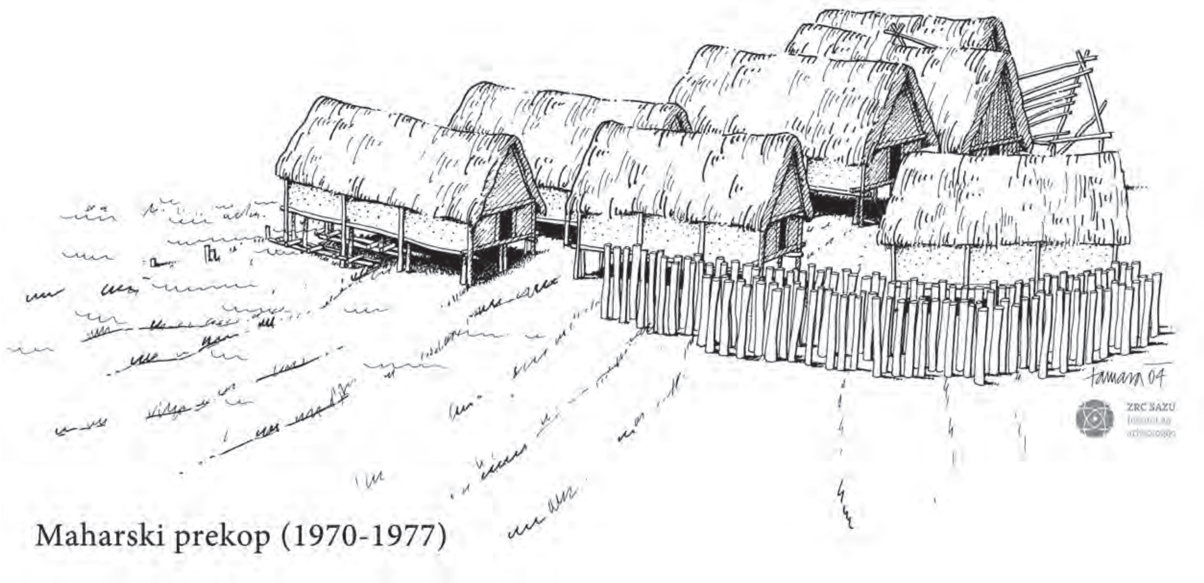

Fig. 2.18: A modern reconstruction of the prehistoric pile-dwelling settlement at Maharski prekop became possible with the introduction of dendrochronology (after Velušček 2005b: 202).

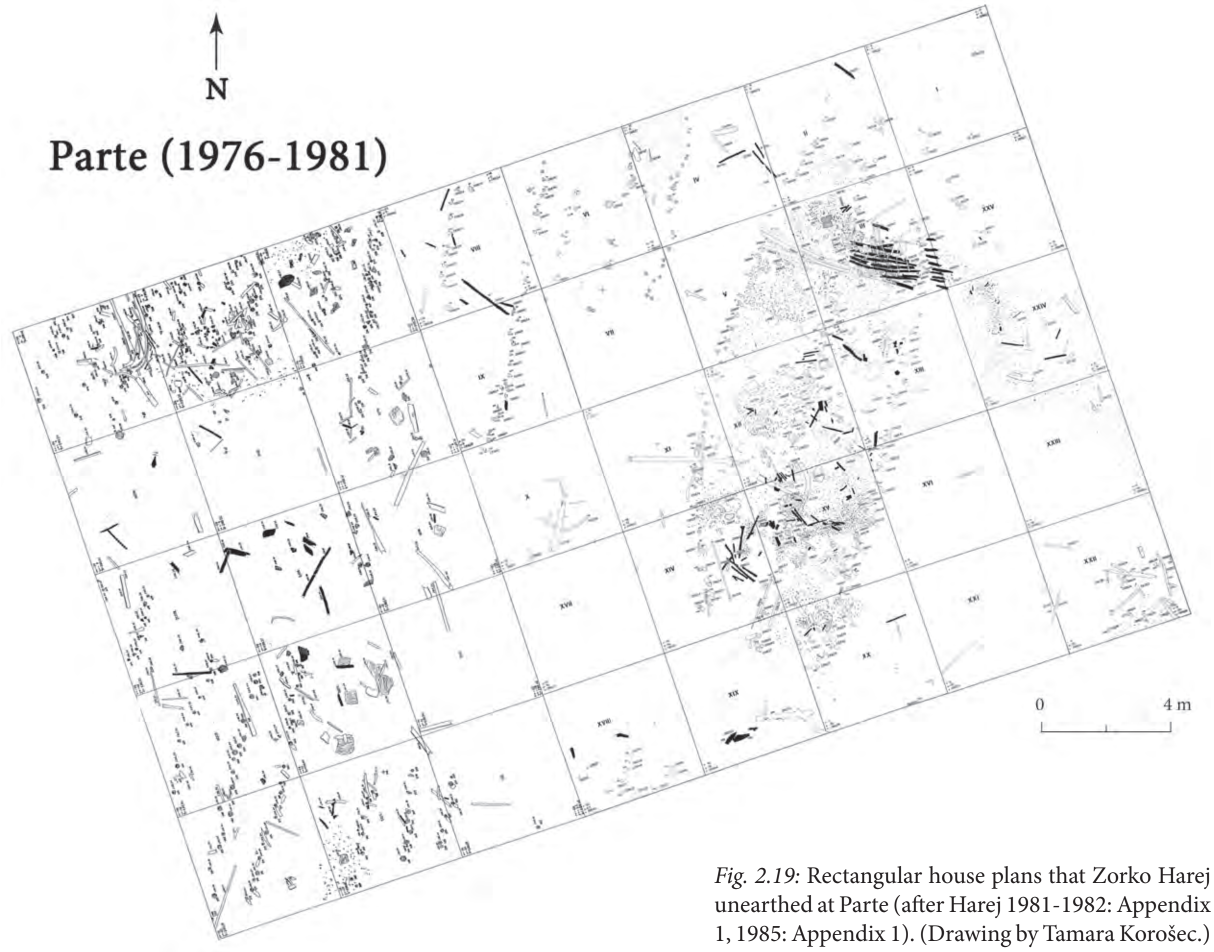

Fig. 2.19: Rectangular house plans that Zorko Harej unearthed at Parte (after Harej 1981-1982: Appendix 1, 1985: Appendix 1). (Drawing by Tamara Korošec.)

[The orientation of the grid squares follows the course of the parallel drainage ditch (after http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso (last visit: 9 June 2022)) and deviates slightly from Harej's orientation (cf. Harej 1981-1982: Appendix 1).]

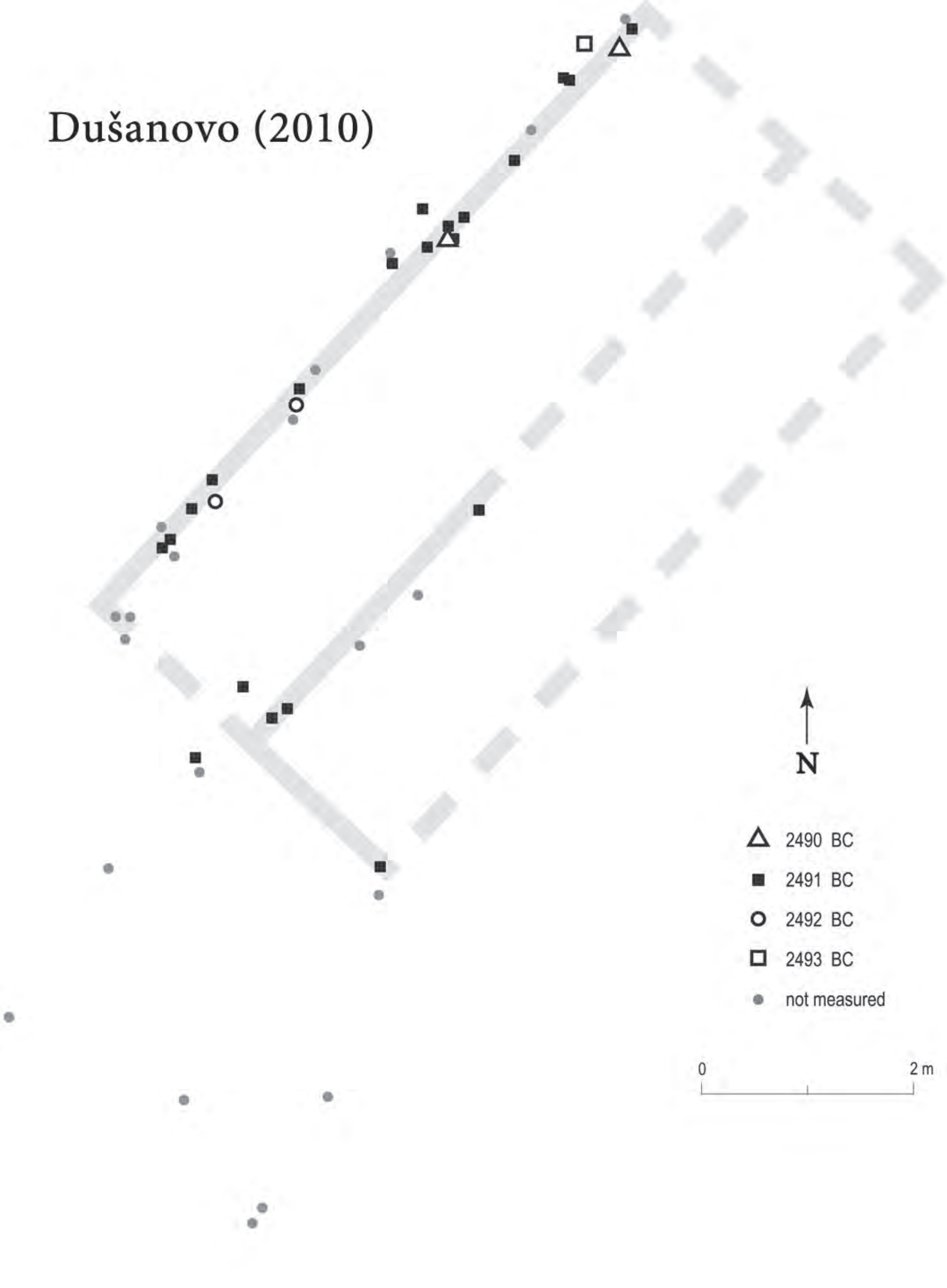

Fig. 2.20: The drainage canal of Črni graben at the site of Dušanovo revealed a part of a rectangular house plan, which dates back to the beginning of the 25th century BC (from Velušček, Toškan, Čufar 2011: Fig. 8). (Drawing by Tamara Korošec.)

While both Ložar (1941b) and Korošec (1955) discussed the house/settlement type on the Ljubljansko barje wetland, the use of a platform was widely popularised by the novel *Bobri* (*The Beavers*) that the famous author Janez Jalen wrote during World War II (Žebovec 2002). As a result, interpretations almost exclusively followed a combination of both views, i.e. the view of Korošec who proposed pile dwellings and that of Jalen who popularised habitation platforms. There are a few exceptions, which received little scientific or public attention. These are the

Pajagič Bregar et al. 2009; Tolar, Zupančič 2009; Velušček, Čufar, Zupančič 2009).

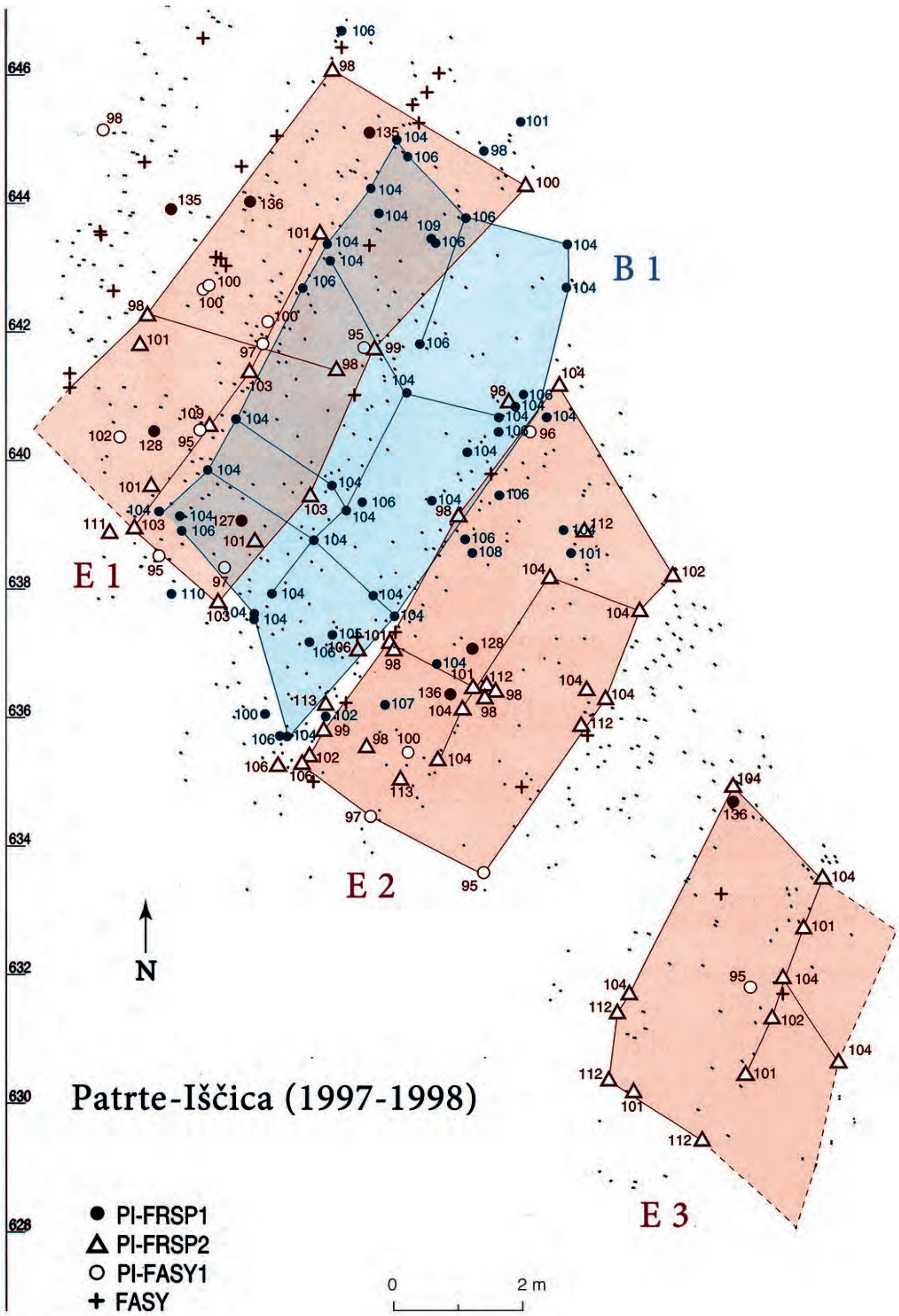

Fig. 2.21: Dating of the piles from the river bed at Parte-Iščica revealed house plans E1 and E2, which were overlapped by more recent house B1 (after Velušček, Čufar, Levanič 2000: Figs. 3, 6 and 8). (Drawing by Tamara Korošec.)

dry land settlements on the river bank at Resnikov prekop and Maharski prekop as proposed by Budja (1994) and a reconstruction of a lakeshore settlement at Špica presented by the Ljubljana City Museum, which offers both possibilities, i.e. a combination of houses on stilts and ground-floor houses on presumably wet soil (see Šinkovec, Zupanc 2011). Dendrochronological evidence proves a dominance of detached houses, while additional evidence supports Korošec's view of dwellings on stilts. In Parte-Iščica, for example, houses E1 and E2 were partially overlaid by the ground plan of house B1 attributed to the subsequent settlement phase (*Fig. 2.21*).

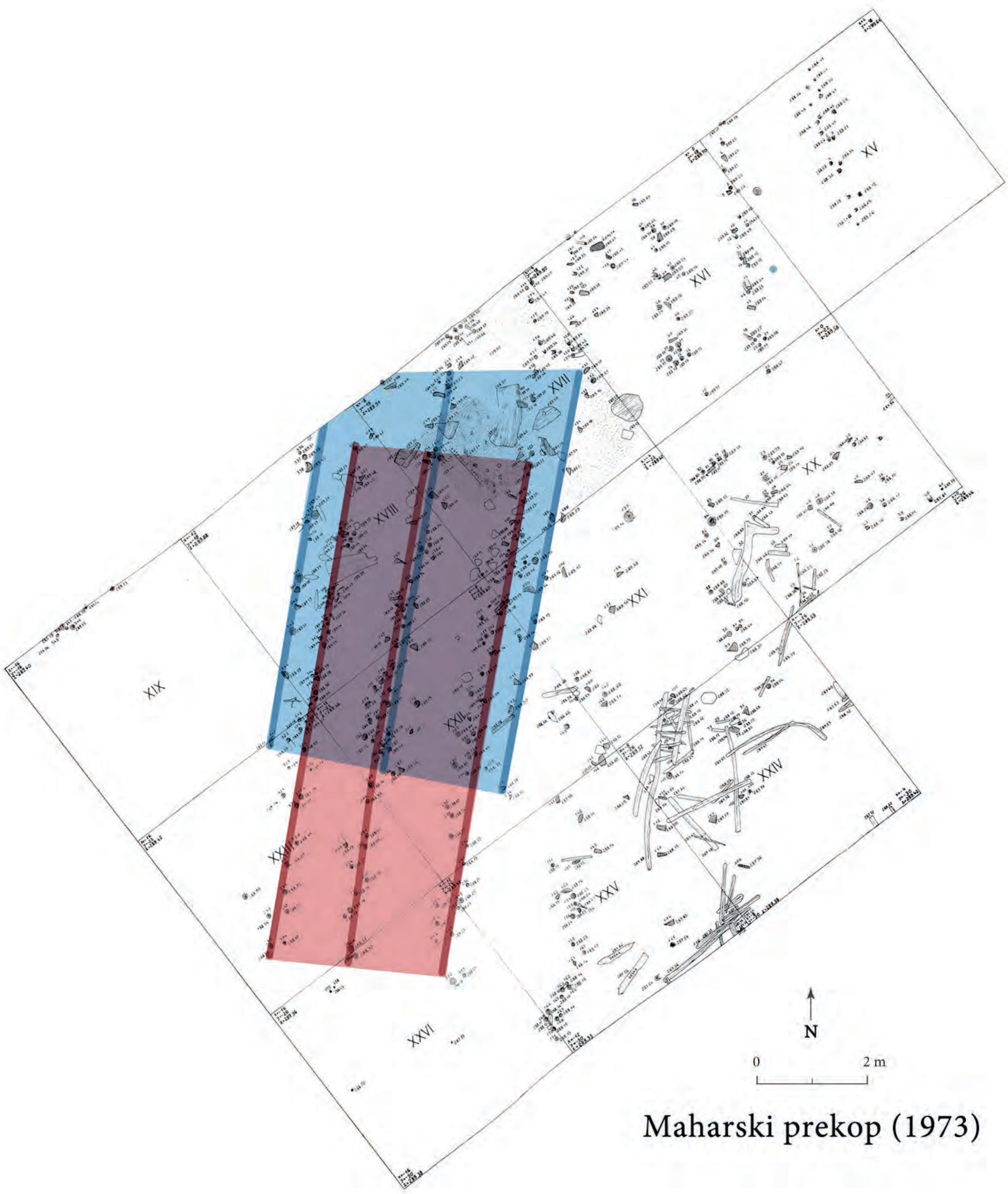

Fig. 2.22: Situation at Maharski prekop in grid squares nos. XV-XIX, XXI-XXIII, XXV and XXVI with partially overlapping house plans of presumably different chronological phases (after Bregant 1975: Appendix 3; cf. Velušček 2001: Fig. 23; Mlekuž et al. 2012: Fig. 6; for chronology of the site see Čufar et al. 2015: Fig. 3). (Drawing by Tamara Korošec.)

[The orientation of Bregant's 1973 excavation plan (Bregant 1975: Appendix 3) is problematic and varies from publication to publication (e.g. cf. Bregant 1975: Appendix 3, 1996: 27).]

In Maharski prekop, where most probably at least two construction phases within the 35th century BC have been documented (cf. Čufar et al. 2015: Fig. 3), two houses in squares nos. XV-XIX, XXI-XXIII, XXV and XXVI partially overlapped (*Fig. 2.22*). At Špica, additional or later piles were driven into the already standing piles (Klasinc et al. 2010: 53, Figs. 30; 31: 2; Šinkovec 2012: Fig. 6); it can be assumed that some substructures of the earlier building activities were still present and visible. They obviously represented an obstacle to new construction. To avoid it, it is reasonable to propose houses on stilts as an acceptable solution in these particular examples.

In conclusion, it should be stressed that although stilt houses probably predominated in the Ljubljansko barje, other house types cannot be ruled out, as we see for example at Lake Keutschach in Carinthia, where a combination of house types coexisted in a single settlement (Samonig 2003). The choice depended, it seems, on the environmental conditions and the needs of the inhabitants.

In the Ljubljansko barje, the piles of prehistoric dwellings are mainly arranged in rows and follow almost exclusively one orientation, namely SSE-NNW. So far, there are only a few exceptions to this rule, either because of environmental factors or because of the special status of a house. Both were discovered in Maharski prekop. One differently oriented group of houses followed the alignment of the wooden palisade (Velušček 2001). Another one is a house believed to have hosted a metallurgical activity; its ridge followed the W-E orientation and is unique within the settlement (Velušček & Greif 1998; Velušček 2008; Toškan, Achino, Velušček 2020). However, the SSE-NNW orientation of dwellings clearly dominates and does not seem to be random. It approaches what is known in the building industry as orientation along the *heliothermal axis*. Despite controversies of its effectiveness and applicability (cf. Harzallah et al. 2012), Andrej Pogačnik (1999: 81; cf. Kos 2012: 41) has shown for central Slovenia that the heliothermic direction is rotated ca. 5° east to the north-south axis. This orientation compensates for the unequal solar radiation of east and west orientations of house facades. Thus, west-facing facades are not overheated in summer, while east-facing ones get more sun in winter (cf. Velušček 2005b: 205, 2020c).

2.4 CONCLUSION

This synthesis discusses some aspects of the research on wetland settlements in the Ljubljansko barje based on almost 150 years of data collection. The main issues of the discussion are the exact chronology, the relationship between the settlement pattern and the lake, and some architectural solutions.

The sedimentological and other palaeoenvironmental data are not discussed at length, but evidence does suggest that the Ljubljansko barje basin held a freshwater lake during the Neolithic, Copper Age and almost the entire Bronze Age. Its remains can be seen in the thick layers of lake marl deposits that are to be found across the wetlands. When the lake completely disappeared, probably in the second half of the 2nd millennium BC, the settlement pattern changed abruptly and shifted, at least from the Middle Bronze Age on, gradually at first and finally exclusively to the dry land on the outskirts and to the dominant hills in the surroundings.

The attractive shores of the lake were an important trigger and incentive for settlement at the end of the Neolithic period in the area and later until the Bronze Age, which occurred in several waves between the first half of the 5th and the second half of the 2nd millennium BC. The first pile-dwelling settlements seem to have appeared in the Ljubljansko barje during the Sava group of the Lengyel culture in the second quarter of the 5th millennium BC. The best known site of this group is Resnikov prekop near Ig. Its first occupation phase was followed by dense settlement during the Furchenstich pottery culture in the second quarter of the 4th millennium. After another, albeit brief, interruption of some decades, another group of settlers appeared around 3500 BC. These were representatives of the Stare gmajne cultural group, which dominated the area until the early 31st century BC. The next occupation horizon in the Ljubljansko barje was in the period of the Vučedol, Ljubljana and Somogyvár-Vinkovci cultures, which lasted from the 28th to the end of the 25th century BC. We do not yet have more precise data on the chronology of settlement for the end of the 3rd and the 2nd millennium, but we can expect a similar dynamic of continuous or recurrent changes in the settlement of the area.

There is much less data on the continuity of occupation within individual phases or horizons. It is unclear whether the Ljubljansko barje was continuously inhabited during the entire period of the Furchenstich pottery culture, for example, or during the similarly densely settled period in the first half and around the middle of the 3rd millennium BC. The only gap identified thus far falls in the time of the Stare gmajne cultural group and is estimated to have lasted between the end of the 34th and the middle of the 32nd millennium BC. The early phase is represented by settlements such as Maharski prekop, Črešnja pri Bistri and the first settlement at the site of Stare gmajne; the subsequent phase is represented by the late settlement phase at Stare gmajne, Veliki Otavnik Ib and Blatna Brezovica.

The question of continuity can also be discussed at the level of a single settlement phase. For example, it is not clear whether the village (prehistoric settlement) at Založnica, which spanned almost the entire

25th century BC according to the dendrochronological analyses, was inhabited continuously for about 80 years or only sporadically during this time period. Despite the 1428 documented and sampled piles, of which about 30% were measured for dendrochronological analysis, it is not yet possible to give a conclusive answer and the question remains open.

The prehistoric settlements in the wetland of the Ljubljansko barje can be described as pile dwellings, where stilt houses with elevated floors prevail. This particular architectural solution indicates an adaptation to the special environment following the needs and capabilities of the inhabitants. It can also be noted that detached houses were built in the Ljubljansko barje from the 5th to the 3rd millennium BC. The possibility of large settlement platforms, as interpreted less than 30 years ago, must be discarded. An important observation also seems to be the predominant SSW-NNE orientation of the houses, which must be considered one of many special skills of the pile-dwellers who inhabited the Ljubljansko barje several millennia ago. Only in one case was it established that the prehistoric village was partially surrounded by a wooden palisade.

Today, seasonal floods are a constant issue in the central part of the Ljubljansko barje plain. A similar situation can be expected for the period of the pile dwellings, when floods probably affected the lowlands around the lake. The settlements, for which there is also little relevant data, stood on intermittently wet soils (Stare gmajne, Blatna Brezovica), some may have stood directly in the open water of the lake near the shore[19].

[19] Some of the settlements that Deschmann researched between 1875 and 1877 could be conditionally assigned to this group.

The archaeological research of the Ljubljansko barje is still very incomplete, both in the wetland and in its surroundings. The most extensive campaigns took place more than a century ago using the research methods valid at that time. An exception is the site of Špica, which was intensively excavated a decade ago as preventive action. Unfortunately, the results are not yet available in the form of a comprehensive scientific study. A long-term, systematic and multidisciplinary research project on a pile-dwelling site remains a desideratum that Slovenian researchers postpone from year to year. The technological development is extremely fast in archaeology and wetland research methods are also constantly evolving. In such a project, it is hoped that archaeology as a scientific discipline on the national level will be able to apply some of these advancements to the study of the pile dwellings. This is indeed already happening, although to a very limited extent.

The prehistoric wetland sites of the Ljubljansko barje are today widely recognised as endangered (cf. Velušček 2015). Without doubt, if we manage to protect them from desiccation and other threats in time, the area of Ljubljansko barje will remain a unique archaeological El Dorado without parallel in this part of Europe and beyond.

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