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On the Emergence of the Castellieri Settlements and Possible Effects of Climatic Changes in the 2nd Millennium BC in the Adriatic Region

Anja Hellmuth Kramberger

Inštitut za Interdisciplinarne Raziskave, Univerza Alma Mater Europaea, Slovenska ulica 17, 2000 Maribor, Slovenia; agrath@web.de or anja.hellmuth@almamater.si

Abstract: The fortified hilltop settlement of Monkodonja, located near Rovinj on the west coast of Istria, Croatia, provides insight into Bronze Age occupation and conflict in the Adriatic region. Established around 2000 BC, as evidenced by a series of C14 dates from human and animal bones, the settlement experienced significant construction phases, particularly in its defensive architecture. Its earliest fortifications, built with limestone blocks using dry-stone wall techniques, date to the 19th century BC, with major expansions in the 16th century BC, where the primary wall was doubled in width and reached over 3 m in thickness. Monkodonja's architectural complexity, notably the West Gate and Acropolis fortifications, and certain types of artifacts reveal influences from southern regions such the eastern Aegean. However, the settlement appears to have met a violent end around the 15th century BC, suggested by destruction layers, widespread burning, and the presence of weapons such as a lance tip, bronze axe, and slingstones. Monkodonja's destruction raises questions about broader military conflicts in the Adriatic region during this period. Possible causes could include localized warfare or connections to larger-scale disturbances. Research in Monkodonja is also significant in the context of the debate surrounding the emergence of the so-called Castellieri settlements in Istria at the beginning of the 2nd millennium BC. As early as the beginning of the 20th century, it was proposed that a migration of people to the Istrian peninsula brought this new settlement form and other influences, leading to a significant population increase. The appearance of the Castellieri settlement form coincides with a period marked by documented climatic changes and two major natural disasters in the form of volcanic eruptions.

Keywords: bronze age; Adriatic region; Istria; phenomen of Castelliere settlements; climate changes; changes in society; migrations

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1. Istria in the 2nd Millennium BC and the "Phenomenon" of the Castellieri-Settlements (Introduction)

Istria is the largest peninsula in the Northern Adriatic, and it owes its name to ancient sources such as the "*Periegesis*" by Hecataeus of Miletus, written between 560 and 480 BC, in which the pre-Roman inhabitants of the region are referred to as *Histri* or *Istri* [1] (p. 45), [2], [3] (pp. 25–27).

Today, the largest part of Istria is located within Croatia, with the northern part largely belonging to Slovenia, and a small area around Muggia in Italy. The sea currents in the eastern Adriatic flow northward and pass Istria along its western coast and it is assumed that they were already used for navigation in prehistoric times (Figure 1) [1] (pp. 49–50, Figure 41), [4] (pp. 13–20). Istria, which geologically consists of limestone, is characterized by sedimented red soil and the typical karst vegetation growing on it, including sub-Mediterranean holm oak and pine forests [1] (pp. 56–58) and [5], (p. 43). The landscape is marked by numerous rounded hills, bowl-shaped karst sinkholes (dolines), fissures, and caves. In the lowlands around the hills, fields for agriculture and livestock farming can be found today.

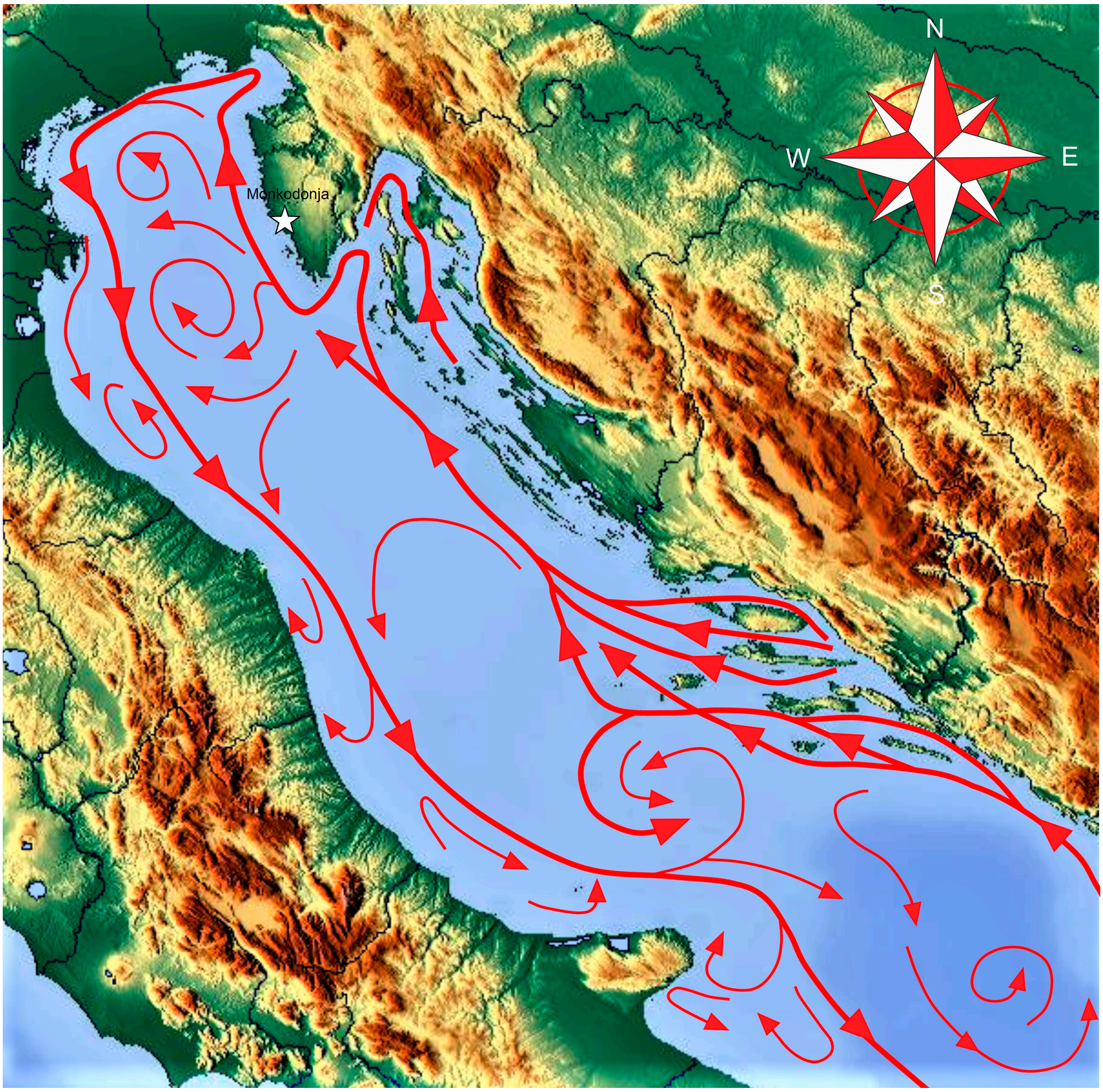


Figure 1. The Adriatic region showing the course of sea currents and the location of the Istrian peninsula (graphic: author, data from [1] (Figure 14)).

From the beginning of the developed Early Bronze Age around 2000 BC, significant changes in the settlement patterns of the Istrian peninsula can be observed: the emergence of a specific type of settlement known as Castellieri, Gradinas, or Kastelliere. These settlements, located on the countless karst hills, are characterized by their thick, often concentric walls built in dry-stone technique—without mortar. Today, these walls are often visible as ring-shaped structures beneath the canopy of the macchia or among the dense vegetation (Figures 2 and 3). By the mid-19th century, over 300 of these hilltop settlements were counted, and today about 500 have been recorded [1] (pp. 27–26, Figure 5), [6,7], [8] (p. 158, Figure 3), [9–12].

On the other hand, it is important to note that in the 19th century, the landscape of Istria looked significantly different than it does today. At that time, the peninsula was less densely covered with vegetation due to extensive livestock grazing [1] (pp. 27, 56–58), [8] (p. 156) and [5] (p. 43). This means that the remains of prehistoric settlements were much more visible, thereby attracting attention and interest.

Figure 2. Aerial view showing the fortified hilltop settlement of Monbrodo, where the concentric walls are covered by the vegetation canopy and clearly stand out in the terrain, Istria, Croatia (Adapted from [13] (Figure 3a)).

The historian and archaeologist Pietro Kandler from Trieste initially speculated in the mid-19th century that the Kastelliere settlements were fortresses to secure the Roman road network [1] (pp. 27–30). This assumed dating to the Roman period was quickly questioned by contemporaries such as Carlo de Franceschi, Tomaso Luciani, and Antonio Covaz, who pointed to the discovery of stone axes and coarse handmade pottery in the settlements. The first scientific study of the fortified hilltop settlements was published in the 1870s by Richard F. Burton, the British consul in Trieste [15]. Burton described in detail the dry-stone construction of the walls and noted that the hilltops on which the settlements are located had been artificially leveled. Burton was accompanied during a visit to the settlement of Kunci near Labin in 1874 by Carlo Marchesetti, a physician and natural scientist, who was the director of the "Museo Civico di Storia Naturale" in Trieste. Marchesetti himself began a systematic study of the hilltop settlements in the 1880s. He registered and mapped over 400 sites and described various settlement types based on their construction, the buildings within the enclosures, and associated necropolises.

The appearance of the new Castellieri settlement type during the Early Bronze Age in Istria, specifically at the end of the Istra I phase according to Čović 1983 [1] (pp. 36, 510, Figure 332), has been recognized by researchers since the late 19th and early 20th centuries as a significant phenomenon, often linked to possible migrations [12] (pp. 123–125). To understand why the emergence of these fortified hilltop settlements in Istria is so remarkable, one must first consider the settlement situation in Istria before 2000 BC. Up until the end of the 3rd millennium BC, Istria appears to have been sparsely populated. Only a few Neolithic and Copper Age coastal stations are known, such as Kargadur (cf. [16]), along with settlement traces on mountain plateaus or cave findings. Most of these consist of finds from karst caves, such as Grotta dei Ciclami/Orehova Pejca [17,18], Laganiši Cave [19], Pupićina Cave [20], Oporovina Cave [21], Garbinovica Cave [22], Pećina Ispod Sela Srbani [23], and Vela Cave [24].

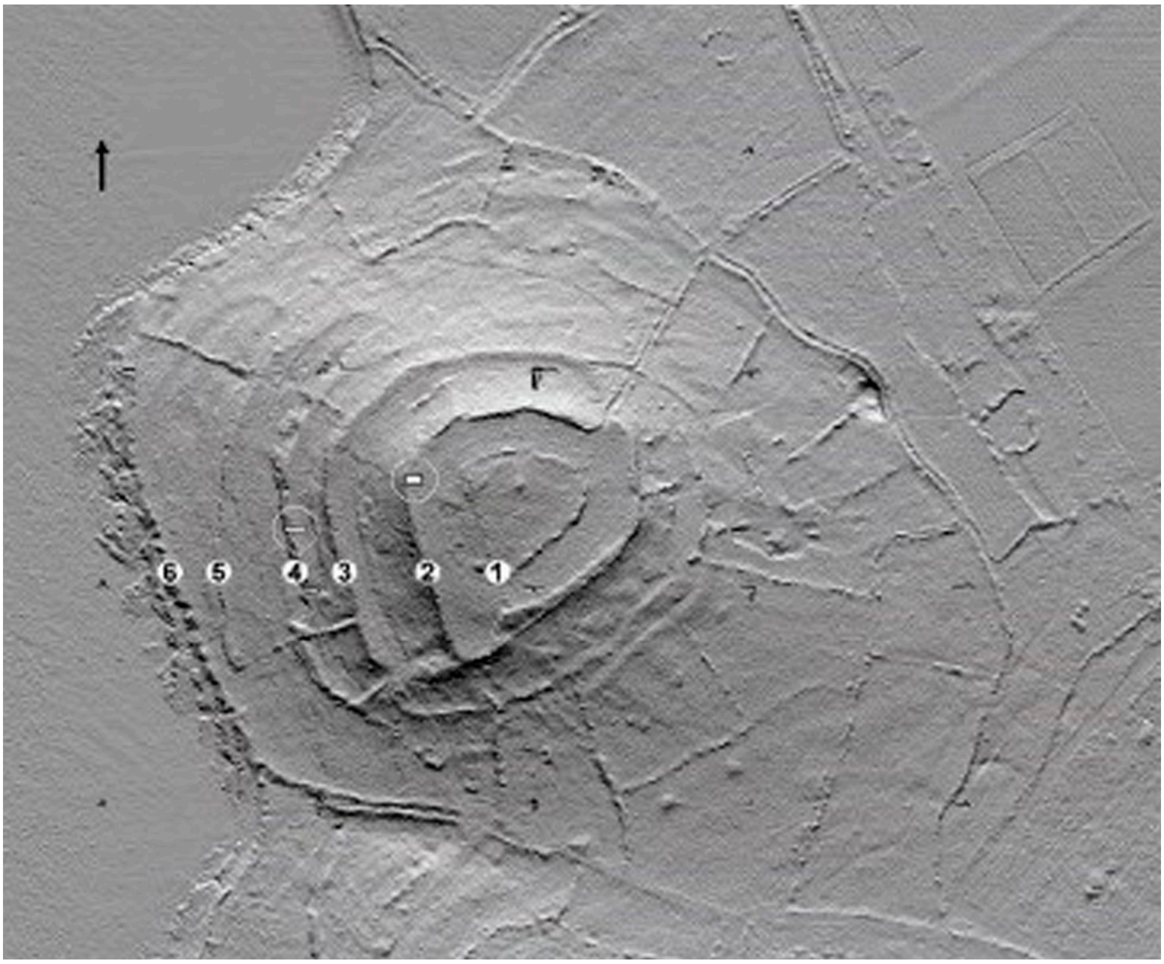


Figure 3. Lidar view of Monbrodo (Adapted from [14] (Figure 2)).

In the Bronze Age, this situation changed dramatically. Not only did the number of known sites increase significantly, but settlements were now frequently found in previously uninhabited mountainous areas [8] (pp. 157–158, Figures 2 and 3). This seemingly "explosive" rise in settlement sites with the onset of the developed Early Bronze Age has repeatedly led researchers to consider that migrations or colonization might have played a role [1] (pp. 30, 494–495), [8] (p. 159), and [12] (pp. 123–125). Although many questions about the Castelliere settlements remain unanswered—for instance, it is still unclear how many settlements were inhabited simultaneously—there are indications that at least some of the founders of the Castellieri in Istria were newcomers. It is suspected that the local population at the transition from the late Copper Age to the Early Bronze Age was too sparse and Istria too thinly populated to carry out such extensive construction projects [1] (p. 494). It is evident that the large-scale quarrying and the construction of meter-thick walls would have required a considerable number of workers, organized and led by specific individuals. Furthermore, the architecture, excavation findings, and artifacts suggest influences from regions as distant as the Carpathian Basin and the Eastern Mediterranean [25,26], [1] (pp. 500–504), and [27] (pp. 337–391). A particularly striking example among the ceramic finds are the tripod plates, which appear in Istria for the first time with the Castelliere settlements and have predecessors in tripods from the Eastern Mediterranean, for example, on Crete and Cyprus [25] and [27] (pp. 215–220) (Figure 4). The use of tripods was likely associated with a specific form of food preparation and culinary traditions that were previously unknown in Istria before the 2nd millennium BC. The Early Bronze Age pottery differs markedly from the characteristic Neolithic and Chalcolithic ceramics of Istria, which were distinguished by striking geometric and curvilinear incised decorations, sometimes with inlays cf e.g., [16] (p. 115). Bronze Age pottery shows distinctly different decorations such as plastic ornaments and fluting, and black polished fine ceramics and barbotine also appear for the first time, to name just a few examples.

Although there is a large number of known sites, only a few have undergone systematic archaeological excavation and much of our knowledge comes from surveys, surface finds—mainly pottery—and occasional rescue excavations (cf 7). Only a very small number of settlements have been investigated through extensive research excavations. In recent years, non-invasive methods, such as geophysical surveys, LiDAR technology, and three-dimensional laser scanning for digital terrain modeling, have been increasingly utilized [28,29] (Figure 3). These methods have provided new insights, such as revealing the frequency of burial mound necropolises near settlements, which were previously obscured by dense vegetation [30] (p. 28). However, due to these limitations, our understanding is still based on incomplete and uneven data.

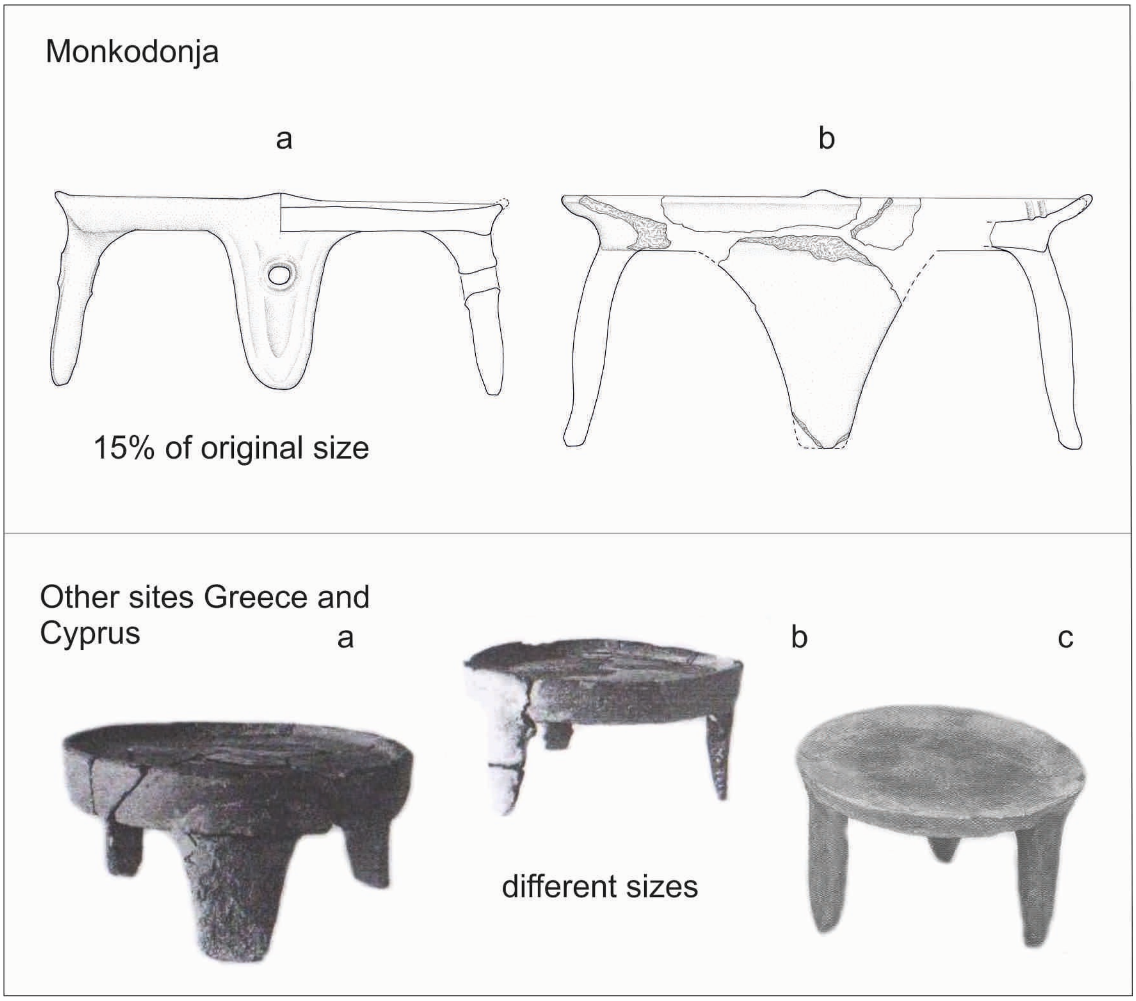


Figure 4. Upper: (**a**,**b**) Ceramic tripods from Monkodonja, Akropolis (Sonda 3), Istria, Croatia (drawings author), lower: tripods from the Eastern Mediterranean region, (**a**,**b**)–Ayia Irini, Kea (Adapted from [31]), (**c**)–Cyprus (Adapted from [32] (p. 50)).

Despite challenges within the existing data, this text seeks to explore the emergence of Castellieri settlements and analyze the factors that might have driven increased settlement activity on the Istrian peninsula from the Early Bronze Age onward. Potential influences on Bronze Age settlement patterns in the late 3rd and 2nd millennia BC include climatic changes and major natural disasters. Additionally, developments throughout the 2nd millennium BC and the question of possible migrations or 'migration waves', as proposed by C. Marchesetti in the early 20th century cf. [2] (p. 117) and [12] (pp. 151–155), will be examined.

The settlement of Monkodonja (Figure 5), the most thoroughly studied archaeological site in the Croatian part of Istria, will serve as a case study for further analysis. Section 2 will provide a brief overview of Monkodonja, following an introduction to the palaeoecology of Istria at the beginning of the 2nd millennium BC. Next, the emergence of Castellieri settlements and the migration-wave theory will be examined, considering the impact of climatic changes and major natural disasters at the transition from the 3rd to the 2nd millennium BC and throughout the 2nd millennium BC.

Figure 5. Aerial view of the fortified hilltop settlement of Monkodonja, with the Adriatic coast visible in the background, Istria, Croatia (Adapted from [33] (Figure 1)).

2. Paleoecology of the Istrian Peninsula and the Gradina Monkodonja in the First Half of the 2nd Millennium BC (Materials and Methods)

2.1. Paleoecology of the Istrian Peninsula

The emergence of the new settlement form on the Istrian Peninsula and the associated postulated population increase had an impact on the natural environment.

As far as the Holocene environment and climate of Istria are concerned, our knowledge is still limited, mainly due to a lack of suitable paleo-ecological sites and research [34] (p. 109) and [35] (pp. 514, 519–520). Pollen and organic remains are rarely preserved in Holocene layers, but there are some sites where human influence is evident in the pollen diagram.

Research at the site of Polje Čepić in the east-central part of the Istrian peninsula, at the northernmost tip of the Adriatic, has shown that at the beginning of the 2nd millennium BC (associated with Core Segment Polje Čepić S3), an open mixed forest landscape predominated [34] (p. 119). In comparison to findings from Core Segment S2 at Polje Čepić, which corresponds to a layer from the 5th millennium BC, a decline in oak and other tree pollen species was observed, with trees and shrubs accounting for 70% of the total pollen count. This decline, along with the simultaneous increase in non-arboreal taxa, where herbs make up 7.3% of the total pollen, indicates a more open landscape. Based on sedimentological and palynological data, particularly the increase in non-arboreal pollen in Core Segment S3, it is suggested that humans contributed to these changes through deforestation [34] (pp. 120–122) and [35] (pp. 514, 519). Similar findings have also been made at the site of Prapoče/Čičarija in northern Istria [35] (p. 511). In the 3rd millennium BC, linden forests (Tilia) predominated, and oak (Quercus), hornbeam (*Carpinus betulus*), hazel (Corylus), fir (Abies), beech (Fagus), and alder (Alnus) were also present. At the beginning of the 2nd millennium BC, the landscape became more open, which is reflected in the decrease of tree pollen in the pollen diagram and the increase of herb pollen.

2.2. Gradina Monkodonja–Research and Dating

In the context of the discussion about the appearance of the Castellieri settlements in Istria, attention must be paid to the fortified hillfort settlement Monkodonja near Rovinj, south of the Limski kanal, which represents the best-studied site in the Croatian part of Istria [1,27,33,36] (Figure 5). The research conducted at Monkodonja has led to numerous new insights, for example, regarding the dating of the so-called Castelliere settlements of Istria, the organization of the settlement, or the long-distance contacts.

In the early 1950s, the first systematic excavations at the fortified settlement Monkodonja were conducted under Boris Baćić, then director of the Archaeological Museum of Istria in Pula [5]. In 1997, archaeological investigations were resumed as part of a Croatian-German-Slovenian joint project funded by the DFG (German Research Foundation) and continued until 2009 under the direction of Kristina Mihovilić (Archaeological Museum of Istria, Pula), Bernhard Hänsel, and Biba Teržan (Free University of Berlin).

A prominent feature of the hilltop settlement of Monkodonja, as well as other contemporary settlements in Istria, is, as mentioned, its defensively effective architecture made of broken limestone, constructed using dry-stone wall techniques. The settlement is divided into an acropolis, upper and lower town, and outer fortification by ring-shaped walls. There may have also been an outer settlement, as indicated by traces observed during the clearing of the macchia vegetation at the foot of the hill. The fortified settlement was accessed through several gates, with the main entrance being the large western gate of the main fortification [5] (pp. 111–251). Also noteworthy are the burial sites—stone cist graves—discovered in the area of the gate [37]. Similar graves have been found in other hilltop settlements, such as Vrčin/Monte Orcino or the Gradina Brioni [37] (p. 161). The architecture of the western gate appears highly complex due to various phases of construction and modification (Figure 6). Such a building form is uncommon for Central Europe during the Early Bronze Age and points southward and southeastward. Complex, repeatedly modified gate structures are also found in the southern part of the western Adriatic, in Apulia, at sites like Coppa Nevigata [38,39] (Cazzella, Moscoloni, Recchia 2012; Cassano et al. 1987) and Roca [40]. Excavators have frequently highlighted the parallels between the gate's construction and findings from Aegina, as well as the parallels between the graves near the gate and those in Mycenae [37] (p. 179), [1] (pp. 174–177, Figures 112–123 with reference to [41]) and [42] (pp. 160–165). It was established that the settlement is not only spatially divided into different areas by the various ring-shaped walls but that within these areas, social stratification can be observed. This can be inferred from the building techniques, as small freestanding single buildings have been excavated, as well as large multi-room buildings with courtyards, which were found in the acropolis area. In certain parts of the settlement, storage buildings were also identified, evidenced by the extraordinarily high number of large storage vessels and animal bones [43] and [27] (pp. 305–318). Most likely, large quantities of food produced in the surrounding area of the fortified settlement were centrally stored within the strongly fortified walls and then redistributed from there [44]. This is an economic system well-known from the Early and Middle Bronze Ages in the Near East and the Eastern Mediterranean.

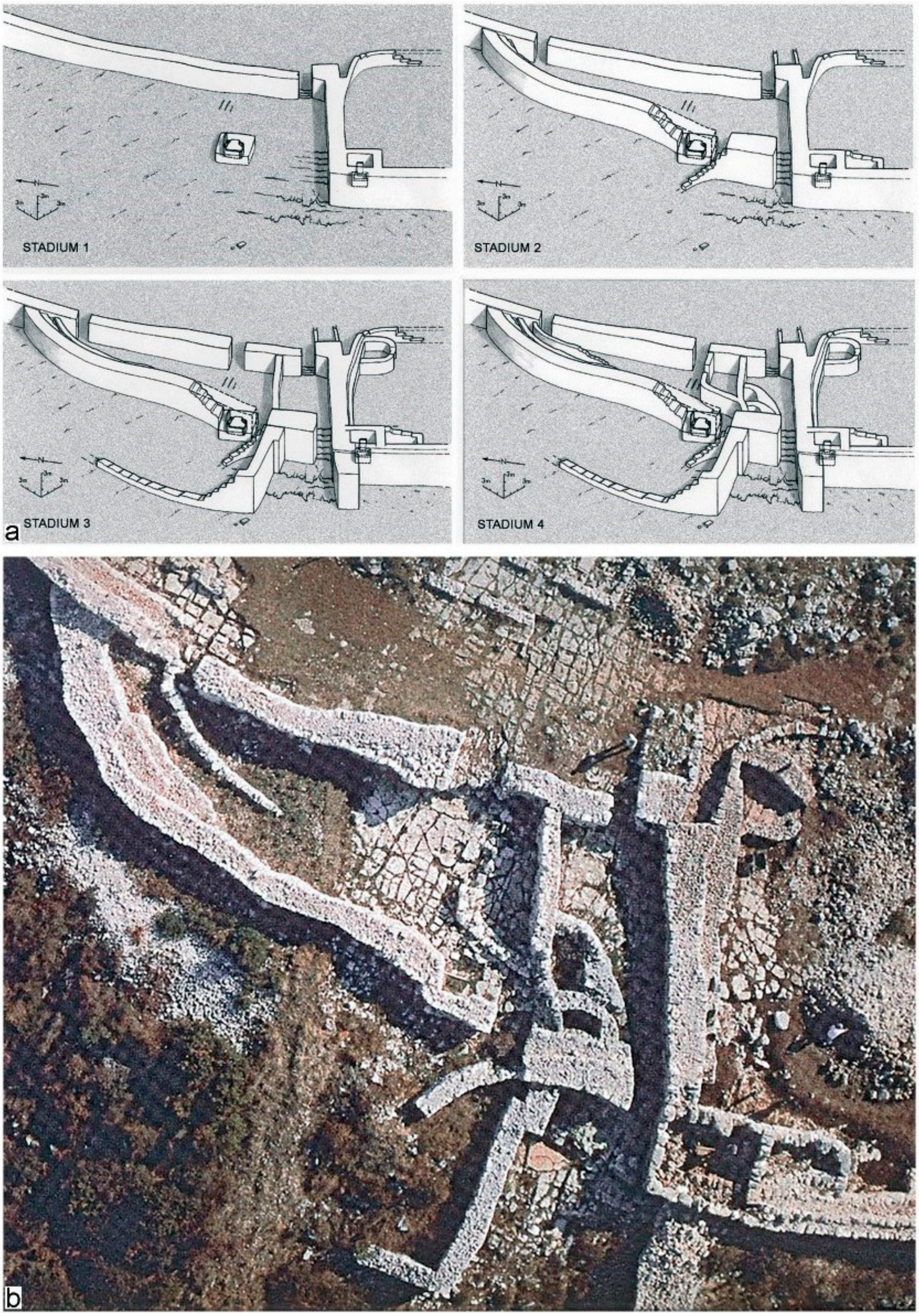
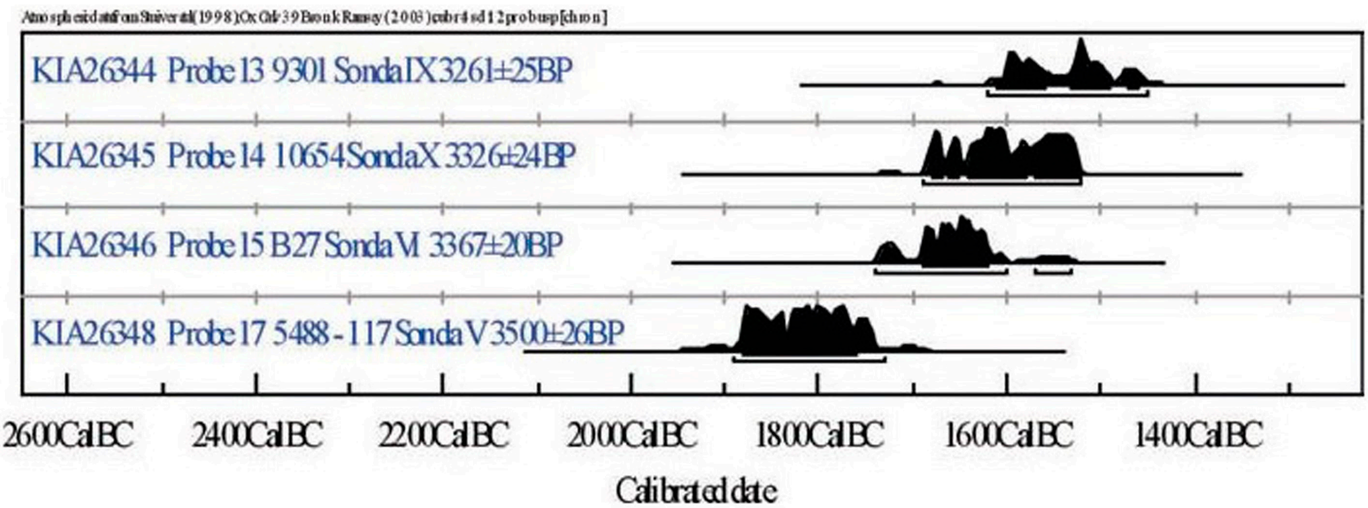


Figure 6. Aerial view showing the excavated area of the main fortification with the west gate of Monkodonja (**b**) and the various expansion phases of the wall and gateway (**a**), Istria, Croatia (Adapted from [33] (Figure 4)).

The gradina of Monkodonja is dated, according to Reinecke's chronological scheme for Central Europe, to the period between the end of Bz A1 and the transition from Bz B1 to Bz B2/C1. This corresponds to the late phase of Istra I to Istra II according to Čović 1983 for Istria and to Bronzo Antico 2 to Bronzo Medio 2 according to Peroni 1994 cf. [1] (p. 510, Figure 332). The Middle Bronze Age, Bronzo Medio 1 and 2 in Italy, corresponds to SH I to SH IIB (Late Helladic I to IIB) in the Aegean cf. [45] (p. 216, Figure 24). A series of 45 C14 dates attest that the settlement was founded around or before 1800 BC, possibly as early as 2000 BC, if we take into account the dating of human bones from the two stone cist graves at the western gate [1] (pp. 141, 146–147, 424–452). These dates were determined under the direction of Pieter M. Grootes at the Leibniz Laboratory for Age Determination and Isotope Research in Kiel, based on animal and human bone finds, and the evaluation of the datings was carried out with the collaboration of Bernhard Weninger (Figure 7a,b).

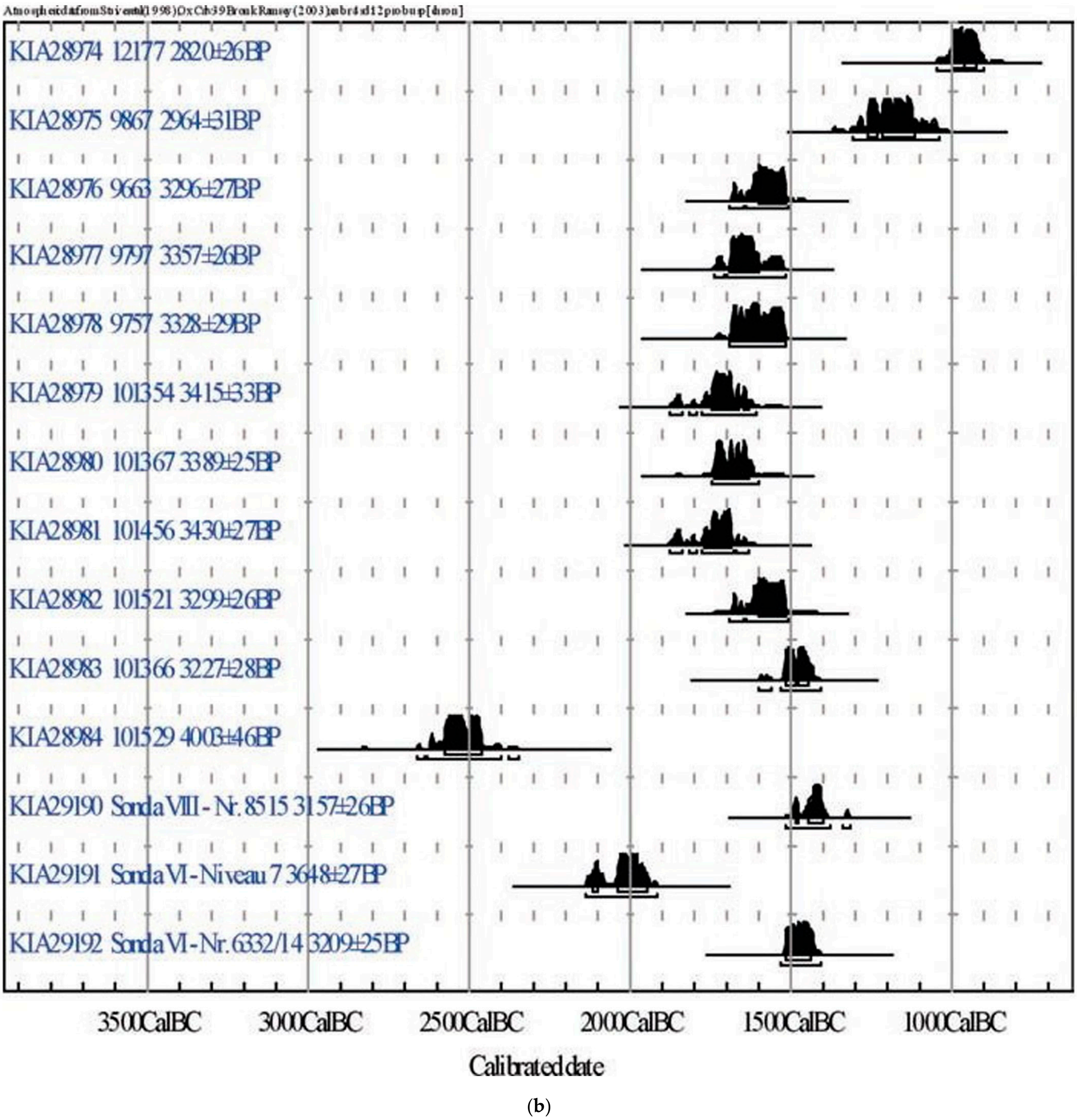
The calibration of the C14 data was conducted by B. Weninger using the program CALIB rev.5.01 with the INTCAL04 dataset, as well as using the program CalPal and the INTCAL09 dataset [46,47]. Eight additional radiocarbon datings were performed by Tomasz Goslar at the Poznan Radiocarbon Laboratory based on human bones from burial mounds in the Monkodonja necropolis from the neighboring hill Mušego and were calibrated using the program OxCal v4.4.2 [48] (Figure 8).

An issue that was thoroughly discussed in connection with the publication of the C14 dates from Monkodonja and the associated burial mound necropolis Mušego, and therefore does not need to be repeated in detail here, is the potential error due to the marine reservoir effect, as fish consumption has been documented in the settlement [1] (pp. 426–427, 438–440, 450). However, unaffected by the marine reservoir effect are the bones of ruminants, sheep/goat, and cattle, and it was found that the 20 samples from the acropolis and main fortification areas of Monkodonja provide a block of relatively close-set dates, which fall within a time window between the 19th and early 15th centuries BC [1] (pp. 438–440, Figures 320, 446 and 447). These dates define the main phase of settlement, with two significantly younger and one older date from animal bones interpreted as results of sporadic visits to the site before and after the settlement's peak period.



(**a**)

Figure 7. *Cont.*



(**b**)

Figure 7. (**a**,**b**): Calibrated C14 dates from the 2005 and 2006 measurements of human and animal bone finds from the fortified hilltop settlement of Monkodonja, Istria, Croatia, Leibniz Laboratory for Age Determination and Isotope Research Kiel (Adapted from [49] (p. 38)).

Among the human bones from two stone cist graves discovered in the gate area of Monkodonja, there are six dates that align with the animal bone dates, ranging from the late 19th to the 15th centuries BC, as well as others that are distinctly older, dating to the late 3rd century BC [1] (Figure 320). The latter should be viewed with caution. In this context, the excavators have also suggested that these early dates might not solely indicate a reservoir effect but may point to specific burial rituals where human bones from older graves were relocated [1] (p. 448).

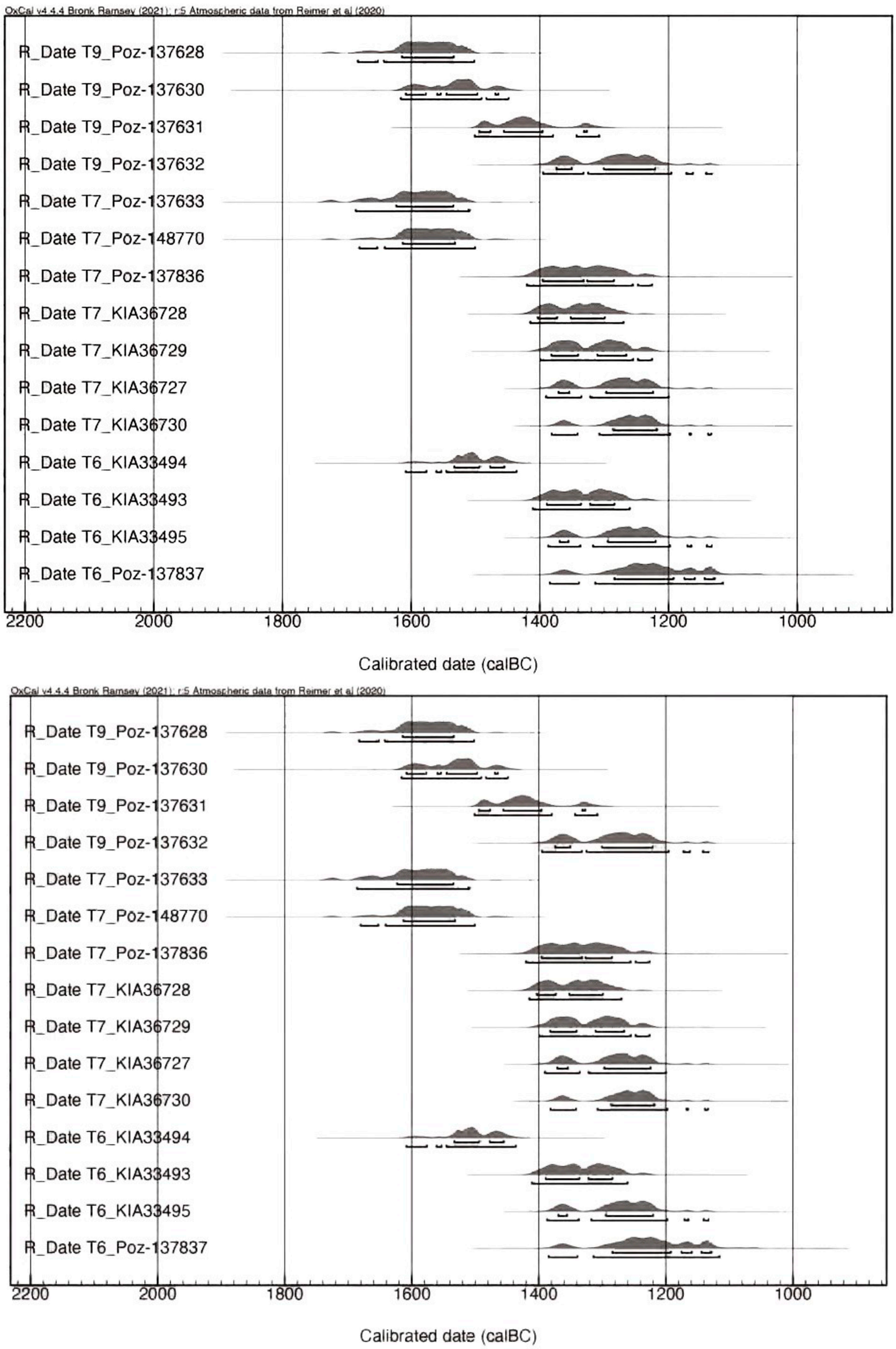


Figure 8. Compilation of all calibrated C14 dates from the burial mounds on Mušego, Istria, Croatia, based on human bones from the Poznan Radiocarbon Laboratory (Poz) and the Leibniz Laboratory for Radiometric Dating and Isotope Research Kiel (KIA) (Adapted from [48] (Figure 4)).

2.3. The Phases of the Construction of the Fortifications

The C14 datings show that the first construction activities on the main fortification wall took place in the 19th century BC, and the earlier phase of the primary use of the site dates to the 18th–17th century BC. The first, oldest wall of the main fortification was built using dry-stone techniques with limestone blocks averaging 60–70 cm in length and 40–50 cm in height. However, in the gate areas, especially at the North Gate, blocks over a meter in length and 60 cm in height were documented, and the wall had an average thickness of 1.50 m [1] (pp. 113–115). In certain excavation areas, the wall was preserved up to a height of 2 m [1] (pp. 120, 122, 127, 137, 143–144, Figures 72 and 86a). In the 16th century BC, there must have been an impulse to significantly strengthen and expand the main fortification [1] (pp. 143–147). The additions on the inner side of the wall doubled its average width, so that in its final phase, the main fortification reached a thickness of over 3 m. The main gate, the large western gate leading into the settlement of Monkodonja, was also extensively reinforced and expanded [1] (pp. 154–155, 158–164, Figures 101 and 102). While in its first, oldest phase the wall only featured a passage through an angled section of the main fortification, in its final construction phase it took the form of a chamber gate with a long gateway flanked by two massive projections or bastions (Figure 6).

Several phases of expansion were also evident in the fortification of the acropolis, during which one gate was closed, and the wall was partially widened to three times its original thickness [1] (pp. 133, 278–301) (Figure 9). Hänsel, Mihovilić, and Teržan point out that the final construction work on the wall in the acropolis area in the 16th century BC appears somewhat hasty due to its slightly varying and less precise construction, suggesting that the inhabitants of the settlement may have reinforced the walls out of necessity and in haste [1] (pp. 304, 446). There is some evidence that the settlement was destroyed in the 15th century BC during a military attack and subsequently abandoned [33] (pp. 111–114) and [1] (p. 452). On the one hand, the C14 data suggest that the settlement was no longer inhabited after the late 15th century BC; on the other hand, the discovery of weapons such as a Middle Bronze Age spearhead, a bronze axe, bone projectiles, sling stones, and extensive burn marks in the acropolis area point to a violent end [1] (pp. 304–305, 349, 506–507) and [27] (p. 308). Likewise, the ceramic spectrum is homogeneous and shows no forms that would date to the Late Bronze Age or Iron Age [27]. It should also be mentioned that numerous human bones were found in all excavated areas of Monkodonja [50]. These include grave finds—burials in the two stone cists near the western gate, destroyed graves, and infant burials—but also human skeletal remains from at least 109 individuals, for which B. Teßmann found evidence that some of these bodies had been exposed to the elements for an extended period and showed signs of animal gnawing [50] (pp. 540–541). This could suggest that some victims of the presumed attack on the settlement might have been left on the surface and under debris after its destruction, without receiving proper burial. It should be noted, however, that this is only one possible interpretation and there may just as well be other reasons for the presence of human bones in the settlement, which are investigated by B. Teßmann.

Figure 9. Aerial view showing the excavated area of the acropolis of Monkodonja, Istria, Croatia (Adapted from [33] (Figure 5)).

3. The Emergence of Castellieri Settlements and Potential Links to Mobility, Climate Change, and Natural Disasters in the Late 3rd and 2nd Millennia BC (Discussion)

Many studies have looked at changes in the environment during the Bronze Age in the Mediterranean and Central Europe, focusing on how these changes affected Bronze Age societies and the links between climate and society (e.g., [35,51–56]).

In the following section, the emergence of the Castellieri settlements in Istria and the theory of migration waves will be discussed against the background of climatic changes during the late 3rd and 2nd millennium BC. For this purpose, a brief overview of climatic changes during the relevant period of time is given, followed by the mention of two major natural disasters in the Mediterranean region in the first half of the 2nd millennium BC, which also had an impact on the Bronze Age population.

3.1. Climate Changes in the Late 3rd and 2nd Millennium BC

In recent decades, there has been increasing research on the occurrence and impact of climate changes and Rapid Climate Change (RCC) events during the Holocene on prehistoric humans, their cultural development, subsistence strategies, and mobility (e.g., [57,58]).

A period during which climate changes are recorded on a global scale includes the late 3rd and the 2nd millennium BC. During the time between 2200 and 1200 BCE, a diverse range of early to late Bronze Age cultures emerged and developed across Central Europe, the Mediterranean, and Western Asia, each contributing uniquely to the broader cultural and historical landscape of the time. Of particular importance and covered extensively in research is a so-called Rapid Climate Change Event, documented for 4.2 ka BP, the 4.2-kiloyear event [51,52,56,59–66]. This refers to a period correlated with the Early Bronze Age in various regions (cf. e.g., [52] (Figure 1), [67] (Figure 3.1), [56], [1] (p. 510, Figure 332), and [68] (Plates 80–83)). Mineralogical and geochemical data from a core (M5–422) taken from the Gulf of Oman document a sudden onset of drought that occurred around 4025 ± 150 BC [65] (p. 382) and [69]. This drought event was evidently short-lived, lasting only a few decades, and may have been the result of large-scale changes in the boundary conditions between ocean, atmosphere, and vegetation. As Cullen and others note, this abrupt climate shift had an unusually large amplitude compared to the rest of the Holocene, almost matching the mineralogical and geochemical amplitudes associated with the Younger Dryas period drought [65]. All available evidence suggests that the 4.2-kiloyear event, marked by cooling and unusual drought, led to dramatic changes in regional climates during the mid-Holocene (e.g., [70–73]). However, it remains uncertain what specific effects these changes had on Early Bronze Age populations in different regions around 2200 BC. As noted above, there is an extensive research apparatus on this topic, discussing the possible impact on the early Bronze age societies in different regions of Europe and Western Asia [56]. Criticism has been directed particularly at oversimplified or generalized interpretations of the connections between changes in the archaeological record and climatic shifts [52] (pp. 333–334), [53] and [35] (p. 519).

For the Late Bronze Age, paleoclimatic data suggest further changes following the cooling phase, pointing to a dry and warm phase associated with the so-called 3.2 kyr cal BP drying event [51], [52] (p. 337), [74] and [57] (pp. 44–48). For the eastern Mediterranean, the destruction of coastal cities such as Ugarit and Tell Tweini around 1200 BC is documented, and these events are connected to socio-economic changes against the backdrop of climatic shifts, which are also discussed in relation to the controverse topic of the so-called "Sea Peoples"(e.g., 50 (p. 4), [74–77]) which, however, cannot be discussed further at this point, as this article focuses on the first half of the 2nd millennium BC. A warmer, drier climate may have led to crop failures and resulting famines in various regions, which in turn could have resulted in increased socio-economic stress and conflicts (cf. [70]). However, the data basis for correlating climatic changes with the disruptions of the Late Bronze Age is sometimes regarded as inconsistent [53] (pp. 11–14) or criticized for assuming that Bronze Age populations lacked adaptability to change [52] (p. 334). Furthermore, high-resolution oxygen and carbon isotope data from a Stalagmite (S1) in the Mavri Trypa Cave in the southwestern Peloponnese, Greece, provide key climate insights surrounding the destruction of the Mycenaean Palace of Nestor at Pylos in the 12th century BC (~3150–3130 BP) [78]. The data suggest that a period of increased aridity following the palace's destruction could have contributed to agricultural challenges and other consequences, such as undermining the ability to rebuild the palace and restore the socio-economic stability of Mycenaean society.

3.2. Natural Disasters During the First Half of the 2nd Millennium BC

Possible effects on Bronze Age societies in the 2nd millennium BC may have been caused also by several documented major natural disasters, such as the Avellino eruption of Mount Vesuvius in Campania, Italy (e.g., [79–81]), and the Minoan eruption (or Thera/Santorini eruption) in the southern Aegean (e.g., [82–85], [42] (pp. 53–62)).

The Plinian eruption of Vesuvius, known as the Pomici di Avellino eruption, ranks among the most explosive Holocene events in the Mediterranean region and had far-reaching impacts on Early Bronze Age populations [79]. The eruption likely dates to the 20th–19th centuries BC, as indicated by a C14 dating of a goat bone from the destruction layer of the Bronze Age settlement Croce del Papa (Nola, Naples) [86] (p. 239) and [81] (p. 814, Figure 7). This dating is supported by an analysis of lake sediments from the Agro Pontino graben, central Italy, which contain a thin, continuous tephra layer composed of lithics, crystals, and a small amount of volcanic glass [80]. The immediate effects of the eruption were catastrophic, and it appears that the devastated areas only became densely populated again in the Middle

Bronze Age, during the Bronzo medio 3 phase, meaning there was significant depopulation or abandonment of the area for several centuries [80,87].

At the end of the 17th century BC, the eruption of the Thera volcano in the volcanic island arc of the southern Aegean marked another volcanic event of enormous magnitude. A Minoan settlement in Akrotiri was covered and preserved by several meters of pumice (e.g., [82–85,88], [42] (pp. 53–62)). The eruption was so extensive that neighboring islands were also blanketed with pumice and ash, and the Minoan ash layer has been detected in numerous sites throughout the eastern Aegean, as far as Anatolia, the Black Sea, and the Nile Delta [83] (p. 43) and [84] (pp. 50, 52, 54, Figure 3). The eruption was accompanied by tsunamis, causing additional destruction over a vast area of the surrounding regions [84] (pp. 54–55). Some researchers, such as W.L. Friedrich [84] (p. 46) and C. Oppenheimer [84] (p. 53), believe that the eruption triggered global climate changes and crop failures, which subsequently led to population migrations in the affected areas.

3.3. Natural Disasters and Climate Change as a Catalysts for Increased Settlement Activity in Istria During the 2nd Millennium BC?

The previous analysis indicates climatic changes occurred during the transition from the 3rd to the 2nd millennium BC, marked by the 4.2-kiloyear event. The impact of this event on Early Bronze Age populations across various regions remains insufficiently understood. Additionally, two significant natural disasters are documented for the first half of the 2nd millennium BC: the Avellino eruption of Vesuvius and the Thera eruption, both of which undoubtedly had immediate and long-term effects on the populations in directly affected areas. These events likely influenced social structures and population movements across the Eastern Mediterranean and Adriatic regions. Notably, these circumstances align with the emergence of the Castellieri—a new settlement form in Istria—and a hypothesized population increase, potentially due to immigration.

However, regarding the rise in settlement activity and the emergence of Castellieri settlements in Istria, a key issue persists: based on current data, we still cannot determine how densely populated Istria was at the beginning of the 2nd millennium BC or the exact number of Castellieri settlements that existed simultaneously.

In the region around Rovinj, it has been established that at least 30 hilltop settlements were occupied during the Late Early and Middle Bronze Age, within an area of approximately 23 square kilometers, with distances between settlements ranging from just 1 to 5 km [37,89] and [1] (pp. 54–55). Excavations conducted between 2016 and 2018 at several coastal sites in this area, as part of a Korean-Croatian joint project, also yielded ceramic finds comparable to those from Monkodonja. These findings indicate at least partial contemporaneous settlement use during the developed Early and Middle Bronze Ages [14,90–92]. This evidence suggests that over the 300–400 years Monkodonja—the best-studied settlement—was occupied, the region indeed had a dense settlement network, with a system of smaller and larger satellite and central settlements positioned within sight of one another (cf. [37] (p. 156, Figure 5)) (Figure 10).

Pollen diagrams currently available indicate that with the onset of the Bronze Age, the rise of the Castellieri settlements, and the suggested population increase, significant changes in the paleoecology of the Istrian peninsula occurred, likely driven by human influence through deforestation. Future research will expand the database, providing deeper insights into these human-induced environmental changes. Nevertheless, these findings already support the assumption of increasing settlement activity on the Istrian peninsula from the beginning of the Bronze Age.

Isotope analyses could provide evidence of mobility or the immigration of newcomers; however, there is very limited data available for the Early and Middle Bronze Age in Istria. C. Gerling and T. Douglas Price analyzed two human teeth from graves near the entrance of the Monkodonja settlement, two human teeth from burial mound 7 at Mušego (the Monkodonja necropolis), and a pig tooth from Monkodonja to examine their strontium (Sr), oxygen (O), and carbon (C) isotope content [93]. The isotope analysis was expected to reveal differences, as it is hypothesized that the settlement's founding generation included immigrants, and the teeth from burial mound 7 at Mušego are younger than those from the graves near the settlement's gate-it is therefore about a "later generation". The pig's tooth was included to provide a baseline for local isotope values, as the pig was assumed to have been born and raised locally in Istria, spending its entire life in the area.

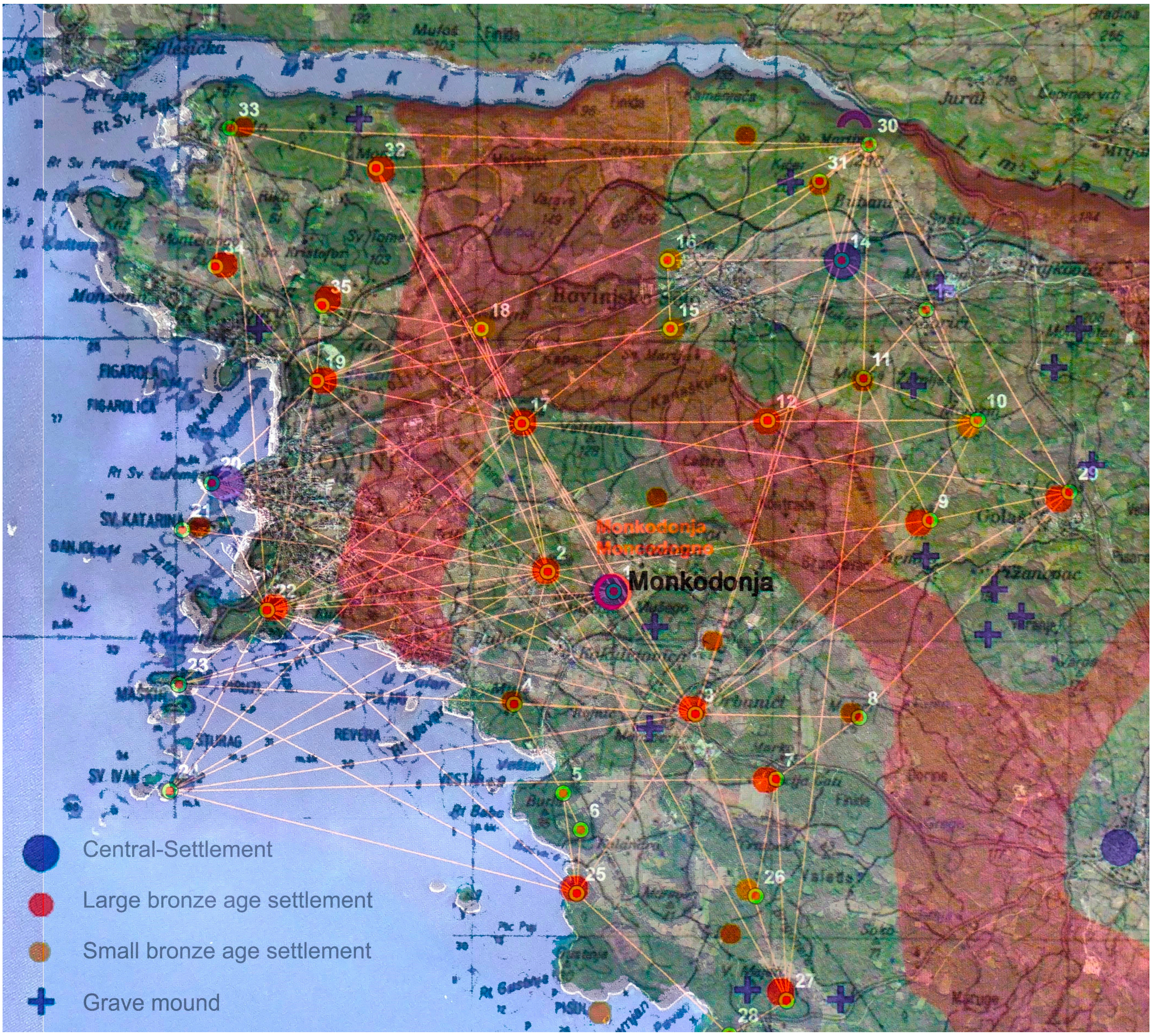


Figure 10. Bronze Age settlement system showing visual communication around the central settlement of Monkodonja, around the middle of the 2nd millennium BC, Istria, Croatia (graphic by the author, Data from [37] (Figure 5) and [1] Figure 17)).

Strontium varies depending on the geographical location or geological substrate, the age, and the composition of the rocks [93] (p. 231). Through weathering processes, strontium enters the groundwater and thus the food chain, being incorporated in place of calcium (Ca) into the hard tissues (like bones or teeth) of living beings. To determine the isotopic signal of biologically available strontium at the location of the first years of life of a human or animal, the first permanent molars (M1) are examined, as the enamel of the first permanent molars mineralizes early in childhood and remains without active metabolism and systematic remodeling throughout life (cf. e.g., [94]). Changes in location can be detected by determining the ratio of stable ^{87}Sr to radiogenic ^{86}Sr. In addition to the $^{87}Sr/^{86}Sr$ analyses, oxygen isotope measurements are also used to determine changes in location [93] (p. 232). It is relevant in this context that the ratio between the stable isotopes ^{18}O to ^{16}O, $\delta^{18}O$, varies depending on factors such as temperature, distance to the sea, altitude, and latitude (cf. e.g., [95] (pp. 80–86)). Thus, information on the oxygen isotope ratios is also incorporated during the time of tooth mineralization, providing clues about the climatic conditions and locations during childhood [93] (p. 232).

The results of the analyses of the strontium and oxygen isotope ratios in the tooth enamel of the four human individuals from Monkodonja and Mušego by Gerling and Price indicate a uniform origin for the investigated individuals [93] (pp. 233, 234–237, Figure 179). Slight differences from the isotope ratios in the pig tooth are attributed to differences in diet. The $^{87}Sr/^{86}Sr$ ratios in the human samples range from 0.70903 to 0.70955, while in the pig, it is 0.70944. $^{87}Sr/^{86}Sr$ ratios for Mesozoic rocks from the Jurassic and Cretaceous periods, which dominate the Monkodonja region, are typically between 0.7080 and 0.7100 [93] (pp. 234, 230, Figure 178). These values align with the geological conditions of the region but also apply to other regions with similar geological backgrounds, making it impossible to deduce different geological origins or mobility of the individuals from Monkodonja and Mušego based on this data alone. However, Gerling and Price also found that the determined $\delta^{18}O$ values of the human individuals, while homogeneous within themselves, deviate from the expected values for the region and the pig tooth [93] (pp. 236–237). The $\delta^{18}O$ values in human teeth range from $-2.43‰$ to $-1.68‰$, with the value for the pig being $-3.93‰$. Converting the $\delta^{18}O$ values to meteoric water yields a range from -3.47 to $-2.24‰$ [93] (p. 236 with reference to [96]), which, according to Gerling and Price, represents a significant difference from the modern oxygen isotope ratio of the region where the archaeological site Monkodonja is situated. The deviations could either be due to inconsistencies in the regression equation used or suggest a southern or western origin of the individuals. To better understand the results, further reference samples are needed, and currently the results do not contribute to the questions about the immigration of the Early Bronze Age inhabitants of Istria.

While ancient DNA analyses are not effective for detecting short-term mobility trends, it is worth noting that studies of Early and Middle Bronze Age populations in Istria have been conducted. As ongoing research examines mitochondrial haplogroups from Monkodonja and other Bronze Age sites in Istria, current findings should be considered preliminary. In collaboration with the Department of Archaeogenetics (DAG) at the Max Planck Institute for the Science of Human History in Jena, researchers V. Villalba-Mouco and W. Haak analyzed samples from 22 individuals across six Bronze Age sites in Istria [97]. These samples include 14 from Monkodonja, two each from Maklavun, Šandalja, and Škicini, and one each from Kavran and Žamnjak. Of the 22 samples, 13 met initial DNA quality criteria and underwent 1240k SNP (single nucleotide polymorphism) capture analysis [97] (p. 166, Table 1). Genetic sex determination identified nine male and four female individuals, and Y-chromosome haplogroups were determined for five males, revealing paternally inherited lineages [97] (p. 168). Notably, male individuals from Monkodonja belonged to haplogroups J2 (MNK011) and J2b (MNK004), from Maklavun to R1b1a2 (MKU001) and J2b2a (MKU002), and from Kavran to R1b1a2 (KVN001). Villalba-Mouco and Haak describe these haplogroups as common in Bronze Age southeastern Europe. It is assumed that haplogroup R may represent a lineage associated with Eurasian expansion into Europe and the origins of prominent Western and Central European haplogroups R1a and R1b, while J2 likely originated in the Middle East [98]. Mitochondrial haplogroups, analyzed for two individuals from Maklavun and one from Monkodonja, included mtDNA haplogroup J1c3 for MKU001, T2b for MKU002 (Maklavun), and K1a18 for MNK007 (Monkodonja) [97] (p. 168). As mentioned above, researches on are still ongoing.

While limited scientific data have yet to provide new insights into mobility and migration in Istria, material culture findings continue to indicate connections with both nearby and distant regions, as discussed extensively by the excavators of the Monkodonja hillfort and the author of this article. As noted, the architecture, excavation findings, and artifacts suggest influences from areas as far-reaching as the Carpathian Basin and the Eastern Mediterranean [25,26], [1] (pp. 500–504) and [27] (pp. 337–391). Regarding ceramics, it is worth to remind once more on the tripod plates, which first appear in Istria with the Castellieri settlements and have predecessors in tripods from the Eastern Mediterranean [25] and [27] (pp. 215–220) (Figure 4). While these findings clearly indicate interaction networks, it remains uncertain whether these connections involved only knowledge exchange or also an exchange of people.

3.4. The Middle of the 2nd Millennium BC-Signs of a Far-Reaching Crisis in the Adriatic Region?

C. Marchesetti postulated as early as the beginning of the 20th century that there were two "waves" of settlement occupation or migrations in Bronze Age Istria (cf. [2] (p. 117), [12] (pp. 151–155)). According to our current knowledge of the appearance of the first Castellieri settlements in Istria, based on the research results from Monkodonja, Marchesetti's postulated first "migration wave" would coincide with the beginning of the 2nd millennium BC. The question arises whether there are indications of other more or less drastic changes in the Bronze Age settlement pattern of Istria, with which Marchesetti's postulated second wave of migration could be linked.

The settlement situation for the late Middle Bronze Age and Late Bronze Age after the 15th century BC—i.e., from Bz C2 according to Reinecke's scheme for Central Europe, or the late phase Istra III according to Čović 1983 for Istria, or Bronzo Medio 3 to Bronzo Recente for Italy according to Peroni 1994 (cf. [1] (p. 510, Figure 332))—is not yet sufficiently clarified. Prior to the extensive research on Monkodonja in the late 1990s and 2000s, scholars assumed that the "phenomenon" of Castellieri settlements was specific to the Middle Bronze Age, and Monkodonja was dated to phases Bz B2-C according to Reinecke's scheme for Central Europe (cf. [5] (p. 117)). However, extensive research and the afore-mentioned series of 45 C14 dates have shown that Monkodonja was already settled in the late Early Bronze Age, Bz A1 according to Reinecke (Figure 7a,b). This late Early Bronze Age and early Middle Bronze Age dating should also be considered for those settlements that yielded identical ceramic finds, such as the Gradina Monbrodo, located about 2 km from Monkodonja and directly on the coast, as well as the settlements of Monvi and Muja [14,90–92], and other sites that have so far been dated based on characteristic surface ceramic finds [8]. Settlement activity at Monkodonja ends in the 15th century BC, but this apparently did not signal the end of all settlement activities in the entire region, as some C14 dates from the burial mounds on the neighboring hill Mušego, which fall between the 14th–13th centuries BC, show [48] (pp. 173–179) (Figure 8). In connection with the C14 datings from the burial mounds of Mušego, which were determined based on human bones, it should also be noted that the first series of 8 datings, conducted at the Leibniz Laboratory for Age Determination and Isotope Research in Kiel and dated to the 14th–13th century BC, was considered problematic [1] (pp. 449–450). They appear too young, especially when a possible reservoir effect is also taken into account. Five additional radiocarbon dates which come from the Poznan Radiocarbon Laboratory are older, they date between the late 17th and 15th century BC which would be contemporaneous with the main settlement phase of Monkodonja [48] (pp. 176–178, Figures 2–4). Two other dates from Poznan fall into a period between the 14th and 13th centuries BC, and are therefore clearly younger than the settlement. Even considering the potential influence of the reservoir effect, some dates from the Mušego necropolis correspond closely to the period of the settlement's existence, at least in its later phase. Additionally, there are dates that are distinctly more recent, suggesting that settlement activity in the area did not entirely cease after the Monkodonja settlement ended in the 15th century BC.

However, no scientific datings and stratified ceramic finds have yet been linked to settlements of the second half of the 2nd millennium, so it is unclear what the characteristic spectrum of ceramic finds at the end of the Middle Bronze Age and during the Late Bronze Age in Istria looks like. Only from the 12th century BC onward is there a broader data base from various necropolises with urn burials, such as from the Limska Gradina [2] (p. 117) and [99]. Based on current data and research, it appears that in the area south of the Limski kanal and between Rovinj and Bale, there was a decline or disruption in settlement activities after the 15th century BC—after the end of Monkodonja.

The question arises whether the presumed violent end of the settlement of Monkodonja involved a military conflict of a regionally limited, local scale, or if it was part of more far-reaching events in the Adriatic region, and what the possible triggers for these events might have been see also [95] (p. 235).

Conflict research and the reconstruction of warfare in prehistoric societies represent a broad field of study, relevant for various time periods and regions (e.g., [100–102]). Destruction layers, burn horizons, human skeletal remains, and the discovery of weapons in settlements can, but do not necessarily, indicate military events. These findings are particularly interesting for the Late Bronze Age and Early Iron Age periods, for which there are not only material cultural records but also written testimonies that point to armed conflicts. For example, during the 13th–12th centuries BC, drastic societal changes occurred in the eastern Mediterranean, and are, as mentioned above, often controversially discussed in the context of the so-called "Sea Peoples". One notable example is the site of Tell Tweini in Syria, where a destruction layer with weapon finds was discovered, dated to this period using scientific methods (e.g., [74,77,103]). For the Adriatic region in the 2nd millennium BC, however, we do not have any written sources that provide evidence of possible armed conflicts, but can only infer such conflicts from material remains.

Of relevance to our considerations are findings from the Adriatic region, which, during a similar timeframe as in Monkodonja, around the middle of the 2nd millennium BC, provide evidence of widespread destruction in settlements that could offer insights into more far-reaching events in this area. In this context, attention should be drawn to the settlements of Roca and Coppa Nevigata in the southern Italian region of Apulia. Roca is located near Otranto, on the Strait of Otranto, the narrow body of water connecting the Adriatic with the Ionian Sea.

The settlement of Roca is situated on a promontory fortified in prehistory and was inhabited from the Middle Bronze Age until the Hellenistic period, up to the 2nd century BC, with a medieval overbuilding also present [40]. The Middle Bronze Age fortification was constructed using monumental dry-stone wall techniques, incorporating post settings, with the wall already having a width of 12 m in its initial construction phase, which was later expanded to 20 m in a subsequent phase. The preserved height of the wall was 3 m, and it is presumed that it was originally at least 2 m higher [40] (Table 7.I), [45] (p. 94). Of particular note is the widespread destruction of the Middle Bronze Age complex around the middle of the 2nd millennium BC, or in the 15th or early 14th century BC during the Bronzo Medio 3 [104] (Figure 3), [40] (pp. 394, 402–403) and [45] (pp. 95, 145). It is highly likely that the destruction of the settlement was the result of an armed attack, during which deliberate fires were set, and the entire complex was burned down [40] (p. 396). In the area of the monumental gate, the skeleton of an armed man was discovered [37] (Figures 3.100–3.101) and [45] (p. 95). Victims of the destruction were found buried under the ruins of the buildings. In the area of the so-called Postern C, the skeletons of seven individuals were found—one man, one woman, and several children and adolescents—who had apparently hidden there and were unable to escape when the fire broke out [40] (pp. 78–86, 399–401, Figure 3.36, 3.54–3.58).

Unlike Monkodonja, however, the settlement of Roca was rebuilt after its destruction, and the fortifications were further expanded. Both for chronology and for indicating long-distance contacts, the finds of Mycenaean pottery are significant [40] (pp. 346–347, 403–404) and [45] (pp. 94–101, 145–148).

Similar to Monkodonja and Roca, a Middle Bronze Age destruction layer has also been documented in the significant prehistoric fortified settlement of Coppa Nevigata, located on the Gargano Peninsula in Apulia. This destruction is dated to around the middle of the 2nd millennium BC or the 15th century BC [104] (Figure 2) and [38] (pp. 459, 462). As in Roca, Coppa Nevigata also shows Late Bronze and Iron Age settlement phases, with the Late Bronze Age settlement, in particular, indicating contacts with the Aegean through Mycenaean pottery [38] (pp. 411–426), [86] (pp. 242–243), [45] (pp. 144–145), [105] (pp. 94–98) and [39] (pp. 131–145). However, based on chemical and petrographic analyses, it has been determined that the Mycenaean-type pottery is not imported from Greece but is instead Italian-made products [45] (p. 144) and [106] (p. 157).

It is overall tempting to link the mentioned examples of destruction of large and likely significant settlements such as Monkodonja, Roca or Coppa Nevigata around the middle of the 2nd millennium BC, both in the western and eastern Adriatic region, and to interpret them as results of more extensive conflicts. However, in this context, the data basis is also severely limited, and it cannot be stated with certainty that all the settlements were destroyed within a closely overlapping time period. However, if we return to the hypothesis of various "waves of migration" to Istria, the data available so far might suggest that after the 15th century BC, there was a certain decline in settlement in Istria, followed by a renewed "upsurge" with the beginning of the Urnfield Culture period.

4. Conclusions

During the 2nd millennium BC, significant changes in settlement activities occurred in the area of the Northern Adriatic on the Istrian Peninsula with the appearance of the so-called Castellieri. As early as the beginning of the 20th century, C. Marchesetti postulated that the occupation took place in the form of two "migration waves", meaning that newcomers migrated into this region, bringing new influences, knowledge, and traditions. It was only with the Early Bronze Age that fortified hilltop settlements with concentric stone walls emerged, which had no precedents in Istria. However, we are familiar with monumental stone architecture from the Early Bronze Age in the fortifications of the Eastern Mediterranean region. No precursors have been found in Istria for the rest of the material culture of the Early and Middle Bronze Age either. For example, if we examine tripod plates in ceramics, these clearly represent a form whose predecessors are found in the Eastern Mediterranean. Furthermore, Bronze Age ceramics in general show no stylistic or technological similarities to the Neolithic and Chalcolithic ceramics of Istria, which suggests the immigration of different ceramic traditions. However, among the ceramic forms, not only are there those that seem stylistically influenced by the Eastern Mediterranean, but also forms and technological features that point in another direction—namely, the Carpathian Basin. Thus, Istria appears as a crossroads, reflecting influences from both the Eastern Mediterranean and Central Europe.

Until the 1990s, research assumed that the spread of Castellieri was primarily a phenomenon of the Middle Bronze Age in Istria. However, extensive modern excavations at Monkodonja, supported by a series of C14 datings, have shown that settlement activities began earlier, in the developed Early Bronze Age, likely around 2000 BC. This shifts the appearance of the Castellieri on the Istrian Peninsula to a time close to the so-called 4.2-kiloyear event, an abrupt climate change event that brought significant cooling and aridity, which may have had more or less noticeable effects in certain regions. The impact of the abrupt climate change on Early Bronze Age societies cannot yet be fully understood, posing a risk of oversimplifying presumed causal relationships. Nevertheless, it seems plausible that the climatic changes were felt more acutely in some regions than in others, possibly leading to droughts and, consequently, migrations in search of better living conditions. The postulated first "migration wave" or the supposed settlement boom on the Istrian Peninsula around 2000 BC could thus be a result of the climatic changes at the turn of the 3rd to the 2nd millennium BC. Based on the current data, it is considered certain that there was a significant increase in settlement activity on the Istrian Peninsula at the beginning of the 2nd millennium BC.

If we accept the dating of the Avellino eruption of Mount Vesuvius in Campania to the 20th–19th centuries BC, this catastrophic event would have also led to migration. However, the material found at Monkodonja, particularly the ceramics, shows no influences from this region. Isolated finds so far only testify to contacts in the direction of Gargano, Apulia [13].

Pollen analyses suggest that at the same time the peninsula began to be settled with the Castellieri, humans began to massively intervene in the landscape, leading to lasting changes. Forests were cleared to obtain building and heating materials as well as for metallurgy and pottery production, transforming the landscape from dense forests to open mixed forests with shrubs and herbs, creating a completely different environment compared to the Neolithic and Copper Age. Human intervention in the environment not only altered the landscape but most likely also affected the habitat of many animal species. Pollen diagrams for Istria in the 7th–2nd millennia BC support that significant human-induced changes in the landscape correlate with the Early Bronze Age in this region.

Around the middle of the 2nd millennium BC, or in the 15th century BC, the fortified settlement of Monkodonja was destroyed, presumably in an armed attack, and was never resettled. During a similar period, other large fortified settlements on the west coast of the Adriatic in Apulia were also destroyed, but they were later rebuilt and resettled. It is not yet possible to determine exactly how close the destruction of the individual settlements occurred in time. However, it seems tempting to see them as the result of far-reaching events and upheavals around the middle of the 2nd millennium BC, which occurred over a relatively short period and affected other parts of the Adriatic region. That settlement activities in Istria, particularly in the area around Monkodonja, did not completely cease after the destruction of the central settlement is indicated by the continued use of the necropolis of the settlement on the neighboring hill of Mušego. The study of surface-collected ceramics and materials from various sondages and smaller excavations in the area south of the Limski kanal and between Rovinj and Bale seems to indicate that most of the surrounding settlements were occupied in a similar time period to Monkodonja and not later, as the spectrum of ceramic forms is identical. Stratified settlement finds that can be clearly assigned to the Late Middle Bronze Age and the Late Bronze Age are not yet available. On the one hand, this results in a gap in knowledge about the ceramic forms after the 15th century BC; on the other hand, no larger finds of settlement ceramics have yet come to light that could potentially fill this gap. Overall, the impression is of a settlement decline after the 15th century BC, but this is still difficult to assess based on the current state of research.

The emergence of the Castellieri around 2000 BC could, in one interpretation, be associated with the abrupt climate changes of the 4.2-kiloyear event and/or the Avellino eruption of Mount Vesuvius in Campania, both of which are believed to have caused population shifts or migrations. However, given the limitations of the current data on population increases and the presumed foreign origin of possible new arrivals in Istria at the beginning of the 2nd millennium BC, it is not yet possible to draw definitive conclusions regarding causality. Similarly, for our second question—what might have triggered a presumed 'crisis' in the Adriatic region around the middle of the 2nd millennium BC, potentially leading to socioeconomic stress, population shifts, and associated conflicts—only speculative assumptions are available at this point, which require further investigation by future research. The Minoan eruption in the southern Aegean at the end of the 17th century BC, while a significant event, appears too early to be directly linked to a presumed crisis in the Adriatic around the middle of the 2nd millennium BC or in the 15th century BC. However, it is possible that both short-term and long-term effects of the eruption influenced regional developments over time, though these potential effects would have interacted with other factors.

While the questions raised in this study about the emergence of the Castellieri settlements and a possible "migration wave" at the beginning of the 2nd millennium BC remain unanswered due to limited available data, the climate changes, natural disasters, and their links to human activity observed during this period could provide a foundation for future research. Future studies should aim to refine these ideas with more precise data to establish clearer causal relationships.

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