Research Article

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Social Organization, Intersections, and Interactions in Bronze Age Sardinia. Reading Settlement Patterns in the Area of Sarrala with the Contribution of Applied Sciences

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Abstract: Bronze Age sites in the coastal area of Sarrala, in Eastern Sardinia, have been subjected to survey and excavation over the last half-century. The study area, whose social and economic evolution and changing scales of interactions are traced through settlement patterns and building analysis, is interpreted in light of more general trends suggested by stable isotopes, archaeogenetics, and paleoclimatology. The local picture of progressive demographic growth and infilling of the landscape, with a subsequent concentration of population and labor, follows a sequence widely detected in Sardinia. More specific identifiable aspects include a comparatively higher fragmentation/competition (ratio of complex vs simple nuraghes; ratio of tombs vs nuraghes) and a consistent pattern in the distribution of non-local building materials in the latest phase at the sites showing archaic features, taken as a clue of a long-lasting authority at select sites. These elements are compatible with organized pastoral exploitation of the available territory, structured according to patrilocality and closeness to ancestral lineages and residences. The interplay of internal dynamics relative to constraints and opportunities is discussed, such as climate change and long-distance trade connections, with possible implications for interpreting Nuragic society.

Keywords: settlement patterns, burial archaeology, Sardinia, Nuragic archaeology, stable isotopes

1 Introduction

The goal of this contribution is fourfold: (a) Provide a detailed presentation of the settlement pattern data for the area of Sarrala, in Central-Eastern Sardinia, including updates and additions to the body of knowledge and a reevaluation of the evidence building on survey and mapping efforts during the last quarter century; (b) propose a deeper interpretation of landscape and social dynamics through quantitative indicators for site types, used to assess various phenomena compared to other regions of Sardinia; (c) employ additional data from recent contributions in the fields of stable isotopes, archaeogenetics, and paleoclimatology; and (d) outline a fine-grained local history in the Bronze-Iron Age, with an emphasis on the scales of interactions and their evolution and intersections over time.

The study area is a section of the East coast of Sardinia, located approximately 63 km Northeast of Cagliari as the crow flies, although the current shortest drive is about 115 km. This is due to the highlands that separate it from the Southern Campidano plains. It lies within the municipal territory of Tertenia, historically part of

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the region of Ogliastra, at its southernmost edge. The study area is essentially defined by watersheds: to the North, it corresponds to the steep Monte Ferru and Cartuccedu, beyond which lie more territories within the Tertenia municipality and then the territories of Gairo and Cardedu; to the West, the watershed is a chain of hills known as Serr’e Mari, and to the South, it overlaps with a low but steep hill, Cuccuru Tundu Mannu. To the East, the Tyrrhenian Sea (details given in Section 4). The broader region of Ogliastra is characterized by its rugged terrain, divided by steep gorges alternating with cliffs and plateaus, contributing to greater difficulty in keeping sustained contact with the rest of the island. Only in Roman times and after the mid-1800s, did Ogliastra have reliable roads linking it to bordering regions, and it also appears as the least affected by urbanization in any historical period – no cities were present even in Punic or Roman times. The specific geology and morphology, coupled with historical factors, also shaped its economic patterns, which, compared to elsewhere in Sardinia, have been characterized by an emphasis on sheep and especially goat pastoralism, and vine and olive groves, more suited than cereals to rocky and hilly lands and relatively poor soils. Ogliastra has attracted recent scholarly and public attention for being one of the blue zones, considered globally as characterized by higher-than-average longevity.

2 Theoretical Background

The Nuragic society of Bronze and Iron Age Sardinia is named after its most monumental manifestation, the nuraghe, a unique site type represented by one or multiple flat-topped stone towers connected by walls, bastions, and courtyards, which number in the thousands. The society they reflect on has been read with various interpretive keys. The main synthetic works on it by local scholars provide ample space for description, focusing the attention on the dialectics between indigenism and external contacts in a narrative historical perspective where the monumental remains and the historic-mythographic sources are significant (Contu, 1997; Lilliu, 1988a; Ugas, 2005). Archaeologists educated in Anglo-Saxon environments or espousing Anglo-Saxon theoretical orientations have used more systematic anthropological models and ethnographic analogy, which is also present, perhaps unproblematically, in much of previous Sardinian archaeological scholarship (Lewthwaite, 1985, 1986; Navarra, 1997; Trump, 1990, 1991; Webster, 1991, 1996b), blending elements from the processual tradition and social anthropology.

A group of scholars more connected to Italian and Spanish academic environments utilizes concepts from Marxist theory to elaborate a social and political reading of the archaeological record, underlining mechanisms of exploitation and early social inequality (Cámara Serrano & Spanedda, 2014; Perra, 1997); other authors employ interpretive keys that represent more empirical, nuanced, or blended elements from the others (Basoli & Foschi Nieddu, 1991; Lo Schiavo et al., 2010; Tanda, 2001; Usai, 1995), including a recent critical review of the old question concerning the prevalence or exclusivity of a domestic vs ceremonial nature of nuraghes (Leighton, 2022).

More recently, an emphasis on the overall weakness of the evidence for vertical social complexity and several clues pointing to the opposite direction has led to depicting Nuragic society as acephalous or even substantially anarchic (Araque Gonzalez, 2014, 2019; Blake, 2015), or as best readable employing more specific models of “house societies” which join the aspects of social inequality inherent in power differential with the heterarchical aspect of multiple players without anyone managing to secure control over vast territories (González-Ruibal & Ruiz-Gálvez, 2016). Ialongo has analyzed population trends in relation to agricultural potential and social agency (Ialongo, 2013, 2018), concluding that reorganization in the Final Bronze-Iron Age transition was needed to reorganize economic activities and avoid economic collapse. Management of religious settings would have been a vital tool for this intent. Finally, the role of burials, whether built, natural, or reused, the importance of interpreting burial customs in a complex relationship with social organization, and the manipulation of memory to strengthen one’s authority have been recently explored systematically (Depalmas, 2020; Lai, 2021a; Perra, 2021).

The problems revolving around the assessment of the intensity and consequences of external contacts and its articulation over time have recently been the subject of different evaluations (Knapp, Russell, & van Dommelen, 2021; Russell & Knapp, 2017; Russell, 2011; Sabatini & Lo Schiavo, 2020), whereas very little attention
has been dedicated to climate change as an essential mover of change. Unlike the Near East, climate is generally marginal as a possible enabler of the constant population growth widely recognized in the Sardinian Middle and Recent Bronze Ages, nor as a constraint and potential catalyst of the crisis in the Final Bronze Age, with a few exceptions (Nieddu, Atzeni, & Cocco, 2016; Webster, 1996a). Some climatic trends detected in the Western Mediterranean had already been tentatively linked to Sardinian developments in material culture (Lai, 2009), and today, a more solid basis is available (Section 8).

3 Previous Research

Covering and discussing the main trends and phenomena in material culture for the Bronze to Iron Ages in Sardinia and the implications of such changes as material correlates of social and organizational change would require at least another paper. Here the focus remains mainly on settlement patterns and how the evidence for monumental building activities has been established based on current literature to set reference points against which local findings in Sarrala were compared.

In continuous evolution from the Bell Beaker phase, the Sardinian Early Bronze Age (EBA) was not characterized by significant architectural development. Contrary to early reconstructions, there is a broad agreement that no nuraghes or giants’ tombs were built during the EBA1 and EBA2, locally named Bonnanaro and S. Iroxi. Furthermore, most sites are represented by pottery in funerary contexts, with scanty evidence for stone architecture and open-air sites in general, ca. 2300 through 1800 BC (Santoni, 2009). In the Middle Bronze Age (MBA1), named Sa Turricula, a slight increase in building activity left visible remains in the realm of funerary architecture, with the possible beginning, in the Northern half of Sardinia, of the orthostatic type of giants’ tombs (Depalmas, 2020; Melis, 2007), which others place confidently only in the following MBA2 (Perra, 2009, 2021). This standardized building type consists of a chamber for collective burial, with a curved façade that describes a portion of a circle around a ritual space. The masonry involves mainly upright slabs and a large stela centrally placed in the entrance segment.

A similar bracket between the later MBA1, but more surely the MBA2, and the MBA3 is the broadly accepted period in which the construction of archaic nuraghes is placed (Depalmas, 2018a; Vanzetti et al., 2014). This phase corresponds to the emergence of monumental visibility for human groups already residing in each territory. The main genuinely monumental phase on a large scale, including nuraghes and giants’ tombs, is placed in the advanced MBA2–3 and the Recent Bronze Age (RBA) (Depalmas, 2018a; Webster, 2016). Giants’ tombs of the type “a filari,” with masonry laid out in rows similar to nuraghes, are considered typical of this phase, continue in the RBA, and their presence covers the central-southern part of the island, matching the diffusion of canonical nuraghes with domed roofing (Perra, 2018c). Whereas structurally, it is often difficult to identify the timing of additions around the central tower which turn a single-towered nuraghe into a complex one, there are examples of nuraghes that have been enlarged after the time of the first foundation (Depalmas, 2018a; Lilliu & Zucca, 2005). In contrast, the original plan sometimes entailed multiple towers (Lo Schiavo & Perra, 2017).

The RBA appears as the last phase of grand monumental efforts concerning nuraghes and tombs, with the focus beginning to switch to ceremonial, water-related sites and the construction of the latest giants’ tombs, built with more finely cut stone in the so-called “isodomic” style (Perra, 2018c). Whereas sacred wells, springs, and villages have yielded traces of presence since the RBA, their construction and most intense use dates mainly to the Final Bronze Age (FBA) and Early Iron Age (EIA) (Depalmas, 2018b; Salis, 2018; Webster, 2014). The RBA also appears to be the phase during which most nuraghes were built, contributing to a broadly recognized capillary occupation of much of the island territory. This has been interpreted as reflecting fission due to demographic pressure in a high-risk, resource-poor environment or as an attempt to increase productivity by planning to establish new centers of agrarian exploitation (see above theoretical perspectives and interpretive arguments). The classification of nuraghes by complexity (Depalmas, 2018a; Lilliu, 1988a; Webster, 2016) has been read as a clue to settlement hierarchy and inequality, possibly beginning in the EBA2 (Perra, 1997). Contrary to this, the lack of signs of differentiation in the treatment of the dead, visible in the collective
burial ritual of the MBA-FBA in both built tombs and caves (Lai, 2021a) and to some degree in the individual burials in the FBA-EIA which still lack significant differences in grave goods besides limited personal items (Perra, 2021), has been considered a key indicator of virtual lack of institutionalized or coercive power (Araque Gonzalez, 2014). Additionally, the abandonment of a large number of nuraghes and the apparent concentration of population and construction activity at a few sites in any given region (Lo Schiavo et al., 2010; Usai, 2018), together with a warrior ideology and the possible existence of religious specialists glimpsed from the bronze figurines and especially the evidence for large-sized statuary (Perra, 2018b) has led to hypothesize greater concentration of power, whether in the form of chieftdoms or “aristocracies.” The concentration of class III nuraghes (Webster, 2016), those most showing signs compatible with defense and control in a specific belt between the central highlands and the Southern and Western plains, had already suggested different levels of complexity, possibly due to unequal environmental and agricultural potential (Lo Schiavo et al., 2010). However, there have been few evident efforts to shed light on region-specific patterns and to underline differential outcomes within the island. This study attempts to highlight such specificity in the survey area.

4 Methods

This study presents new unpublished data on settlement patterns, the outcome of a thorough survey between 2006 and 2013, which were built upon previous research. The data are then interpreted in light of a review of recent developments in biochemistry, genetics, and paleoclimatology, which help contextualize the patterns in the broader economic, demographic, and environmental dynamics to inform an outline of spheres of interaction that intersect and overlap at different scales.

The unit selection follows geographic criteria, and the presence of a likely cluster of nuraghe makes the region defined by the watersheds described above a reasonable organizational unit also in the Bronze Age. It is also surrounded by more sparsely inhabited spaces that have already been recognized as potential buffer zones between polities or tribal/descent groups (Bonzani, 1990; Usai, 2015, 2018).

Sàrrala, in Eastern Sardinia (Figure 1), is an area essentially defined and circumscribed by physical features as a meaningful study area. Its surface is 26.93 km², which consists of a core of low-lying arable

Figure 1: Left: Location of the study area within Sardinia (map from maps-for-free.com, elaboration by L.L.). Right: Satellite map of the study area, from Google.maps, under fair use license. The lowland cultivated areas are distinct from those covered by wild vegetation. The coastal basin defined by the watershed around the area is identified as a likely Bronze Age territorial unit.
land (currently farmed or developed), bordered by variably steeper hills to the North, West, and South and the Tyrrenian Sea to the East. A clearly defined ridge and watershed, named Serr’e Mari, runs North-South at the identified western border, with a few easy passes leading through two intermediate small valleys to the wider Quirra River valley. The latter also runs parallel in a North-South direction, with the stream keeping a distance of about 5–6 km west of the shoreline. The two secondary valleys are named Corriga, with the winding Riu Sibiri and Baccu Longu, which runs almost parallel to the coast before flowing into the Quirra River to the Southwest. Several smaller ridges and hills depart from the main chain, which is steep but lower than 600 m a.s.l. To the North, the stark natural barrier to communication and geographic border corresponds to the rocky formations of Monte Ferru (875 m a.s.l., the highest peak in 15 km radius) and Cartuccedu, with a single pass in between. On the coast, two large bays, Fogi Manna and Fogi Murdegu, provided the easiest landings for seaborne vessels, separated by a prominent steep hill, running parallel to the coast, which for its dominant position was historically used as a sentry location (Guardia Manna). The Southern border of the study area is less steep. It corresponds to the most evident narrowing of the coastal farmland, marked visually beyond the measured altitude by a steep, regular hill named Cuccuru Tundu Mannu, almost 200 m a.s.l. and less than 650 m from the current coastline. Much smaller pockets of arable land are also present more southerly, beyond the Tertenia municipal border, with the Western hills narrowing their distance from the coast. The imposing character of Cuccuru Tundu Mannu made it an ideal territorial marker in the 1830s subdivision of territories among several municipalities that had exploited it in common for centuries. Therefore, the area’s historical definition corresponds to actual, clear geographic borders.

The geology is dominated by schists and granitic formations, with alluvial deposits in the central lowlands. Relative to the dolomitic formations several miles inland, in these types of bedrocks, somewhat fewer springs are present, which may have had consequences for the area’s early settlement. Small coastal lagoons were present up until post-World War II times, when the advent of mechanized agriculture led to their infilling, and simple, low-tech reconstructions of the coastline for Phoenician-Roman times (Bartoloni, 1996) suggest that the sea may have reached considerably more inland; however, no geoarchaeological study has been carried out as yet.

Much of the area until the mid-1900s was cultivated in rotation every few years, to a large extent communally, with slash-and-burn techniques aimed at clearing the land from the bushes that grew during the intervals between farming cycles, which were around 5–10 years. Some pockets of hardwood were spared, and areas with more mature shrubs and wild olive trees were also present. The area has been transformed mainly in the 1960s through the 1990s, first by agriculture, then by touristic development, largely unregulated; the two phenomena are responsible for much of the destruction of archaeological sites, many of which are known from a critical publication (Cannas, 1964) to have been still visible around 1960.

The survey included the following steps: review of previous publications resulting from informal survey, which were a guide for the verification of the mentioned sites (Basoli, 1984a; Cannas, 1964, 1972, 1989), and from early excavations at a few sites in the area, which yielded scarce stratigraphically sound data (Basoli, 1980, 1981, 1984c; Contu, 1967, 1968) but contained descriptions of known sites (Basoli, 1984a,b), and selective survey, identification, recording, description, and mapping with traditional, low-tech instruments in 1999–2001 and 2006, relative to the nuraghes in Southern Sarrala and the coeval giants’ tombs of the whole area; more intensive survey and systematic recording and GPS positioning of sites on the entire area in 2010–2013, covering smaller areas less accessible due to property fences or thick vegetation and with selective use of drone aerial photography. Attention was paid to describing structures and noting any surface finds, some of which were technically drawn during the 1999–2001 campaign, and information was collected from the residents or those who may have known the surroundings of any site for a variety of practices from cultivation to herding to hunting, so that local knowledge was incorporated in the research and guided the exploration, and monuments no longer observable were also recorded. Nuraghes (and, to a lesser degree, giants’ tombs), whose preservation allowed us a reading of the architecture, were examined to investigate their building history and assigned to relative phases, described below. Though inter-visibility between sites was recorded, no viewshed analysis was carried out with digital instruments. More specific spatial relationships were recorded with environmental features as water sources and with other sites.
The survey and partial mapping evidence are included in two theses (Crispu, 2013; Lai, 2001) and only preliminary data on the giants’ tombs (Crispu, Sanna, & Lai, 2011). Some trends already outlined (Lai, 2013) are presented more extensively, with additions and updates based on the most recent surveys and excavations (Basoli & Crispu, 2012; Crispu, 2013).

This study interprets the evidence of settlement patterns in light of the new data from stable isotopy, archaeogenetics, and paleoclimatology. Stable isotopy provides initial data on human dietary patterns and animal management practices. Archaeogenetics in the last few years has made vital contributions to the understanding of the peopling of Sardinia and gene flow and genetic drift with particular reference to Bronze Age population structure (Chiang et al., 2018; Fernandes et al., 2020; Marcus et al., 2020; Olivieri et al., 2017). Paleoclimatology appears increasingly relevant for explaining Bronze Age economic and social developments in Sardinia, with a growing consensus on the existence and role of stability vs rapid climate change (RCC) events, such as those at 4.2 and 3.2 kya. The importance of understanding climatic variation to examine its relevance to constraining human action and to enable or suppress specific options available to various agents has been suggested on circumstantial bases (Lai, 2009; Webster, 2016). Now despite the persistent lag in our direct knowledge from data originating in Sardinia, a few studies do highlight general trends (Beffa et al., 2016; Pedrotta et al., 2021), but mostly it is clear that even without fine-grained details on local patterns, there are broad, overall trends that can be safely believed to apply to Sardinia.

These different strands of evidence are woven in a complex history of the interplay between human organization, economic practices, ritual, and climate to outline local developments that may also suggest interpretive keys of broader relevance for understanding general trends in Bronze Age Sardinian society.

5 Survey Data

The history of building activity in the area during the Bronze Age – possibly EIA has only been briefly outlined prior (Lai, 2013); here we provide additional data within the same methodological and interpretive framework (Figure 2, details in Supplemental materials), based on surveys in the last 15 years.

Phase I includes only three structures showing archaic solutions compared to canonical features (see below Phase II): Nur. Anastasi, Nur. Barisòni (Figure 3), and Nur. Longu. They correspond to architectural elements in monuments elsewhere described and labeled as “protonuraghi” or corridor-nuraghes (Manca Demurtas & Demurtas, 1991; Manca Demurtas, 1991; Ugas, 1999). Nuraghe Nastasi’s central tower (C) may not have been a proper tower. Unless this is not an artifact of restorative work between the late 1960s and 1970s (Basoli, 1980; Contu, 1968), a ledge along the inner side of the circular wall would make it impossible for it to support the weight of a domed roof, so that a cover built with beams and perishable vegetal materials appears likely. In any case, the plan lacks stairs accessible from indoors, and the typical large niches make Tower C at Nur. Anastasi analogous to Sa Corona – Villagreca, Nuraminis (Carta, 2015). These features suggest that the establishment of this structure might have occurred before the standardization of such elements. Employing large, barely shaped boulders in the lower sections of the masonry in Tower C and the two added rooms (B and G) (Lai, 2001) may point to an early date for all three of them. Tower A at Nur. Barisòni (Figure 3) features the standard staircase but a slanted plan and an entrance corridor covered with flat slabs up to the ceiling top instead of the canonical tholos vault (Crispu, 2013; Lai, 2001; Melis, 2002). This central structure was partially damaged and repaired later when basalt became available, and a large addition was built, as is visible in the difference in masonry texture and material (see Phase IV). At Nur. Longu, the archaic phase is not readable clearly. Still, the elongated shape of the foundational building seems compatible with a boat-shaped corridor nuraghe of the type evident at Nur. Barisoni (Crispu, 2013). Comb-impressed pottery from Nur. Anastasi (Campus & Leonelli, 2000) suggests an early presence toward the RBA (Depalmas, 2009b).

Phase II can be characterized by the proliferation of several single-towered standard nuraghes (Supplementary materials; Figure 4). Although in some cases, it is impossible to verify all elements, the presence of a regularly circular plan and the staircase has been taken as a clue for this identification; masonry is more regular, with large stones that are; however, usually smaller, better shaped than the large
boulders at Nastasi, rooms C, B, and G. These nuraghes may show regular towers with a circular plan (e.g., su Tettiòni), an identifiable staircase running within the wall, opening to the left side of the entrance corridor (e.g., Sa Cannera), and structures compatible with a domed ceiling. There are several nuraghes that cannot be adequately read but can be attributed tentatively to this phase based on the visible volume of stone, on
which basis they are likely to be or to have been, single towers (e.g., Punta Is Ebbas; Pissigorru; Sa Picca; Punta Morus; and others in Supplementary Materials). This phase corresponds to Webster's phase of demographic growth and related multiplication of nuraghes in the landscape (Webster, 1996a, ch. 6). As has been highlighted (Ialongo, 2018), fission is a standard solution in societies organized patrilineally and patrilocaly when conflicts or population growth make it worthwhile to split inherited resources (in this
case, land or use rights on it) and set up new settlements (Sahlins, 1961) which usually maintain ties with the origin center and with the parallel centers by lineage and kinship, but may also weaken such relations. Other views consider the process more hierarchically managed as truly planned enterprises to the point of constituting authentic top-down programs of agrarian colonization of new land (Perra, 1997, 2021; Usai, 2003, 2012, 2018).

Phase III can be characterized by additions made at several sites around the central tower, indicating some degree of expansion; among such nuraghes are Nur. Su Concali, Nur. Su Lionagi, and Nur. Orruttu (Supplemental materials; Figure 5), possibly Nur. Anastasi – if rooms B and G were not already in place. The distinction relative to phase II is essentially structural since some sites may have experienced building activity at different times, and a short or extended time may have lapsed between the construction of the central tower and the additional ones; some nuraghes may have been planned as complex from the start, as in the case of Nur. Arrubiu, Orroli (Cossu, Campus, Leonelli, Perra, & Sanges, 2003). Furthermore, the main discriminating factor between Phase III and IV is the building stone, which is only local in the former. Even with no contribution of excavation data, claimed to have yielded no intact stratigraphy (Basoli, 1980), this structural phase and its relative chronological placement can be assessed by analysis of stratigraphic relationships between visible building units at Nur. Anastasi. No basalt was employed in the first additions to the central tower C (rooms B, G, and areas A and F). The building technique of the tomb near Nur. Su Concali provides one

Figure 4: Nur. Sa Cannera and Nur. Su Tettioni, both single-towered – although the former shows terraces that future investigations may reveal as additional rooms. They are both circular; Nur. Sa Cannera also shows canonical staircase on the left side of the entrance and one niche under the stairs. These traits have been attributed to Phase II in the local sequence – original figures in Lai, 2001, with permission.
Figure 5: Nur. Su Lionagi and Nur. Orruttu, two examples of nuraghes possibly built as a single tower in Phase II, to which a structural body was added, including several rooms/towers around a courtyard, during what has been named Phase III. Only excavation could enable in the future to verify each site whether a significant temporal gap was present between building phases – original figures in Lai, 2001, with permission.
indirect element for the relative dating of this phase. It appears to be built with upright slabs rather than horizontal masonry courses like the few other readable giants’ tombs. This suggests that most settlement fission and multiplication or colonization events in Sarrala plausibly occurred within the RBA.

Phase IV is characterized by the use of basalt in the structures and is represented by the last additions to existing structures at only six sites (nuraghes Anastäsi, Barisóni, Longu, Baleri, Marosini, and the monumental well of Sa Brecca; see Supplementary materials; Figure 3). These nuraghes show the addition to the central tower of one or two courtyards and two to four rooms/towers. This group is similar to Phase III structures regarding room arrangement, but building material is the discriminant point. The presence of basalt has been recognized for decades (Basoli, 1980; Cannas, 1972; Contu, 1968). It was recorded systematically in 2001 in Southern Sarrala (Lai, 2001) and later at the well of Sa Brecca (Basoli & Crispu, 2012; Salis & Crispu, 2020) and Nur. Marosini (Crispu, 2013). The four nuraghes with basalt wedges are relatively evenly spaced, at an average of about 1.5 km from one another, with the many Phase II and III nuraghes around or between them at shorter distances. At Nur. Anastasi, room E and especially D are rich in basalt wedges. Their clear stratigraphic relationship with C and with the structure around entryway A makes them unambiguously the latest addition to the complex (Lai, 2001), and a similar pattern is observed at Nur. Aleri, Nur. Longu, Nur. Barisoni, and Nur. Marosini (Crispu, 2013). Despite the lack of geochemical sourcing, such basalt can safely be considered as transported from the Tecu plateau 20 km to the North due to both physical properties at autoptic examination and the continuous distribution from that source through the surveyed area, in contrast to alternative basalt sources being much further and with no record of continuous distribution in the interposed area in Nuragic structures (Pran’e Muru area, Orroli).

An inference that can be made from such a pattern in Phase IV is that only the communities gravitating around those sites had the organizational capacity, the labor for actual construction, and the means, rights, and relationships needed to import basalt by sea from a significant distance along the Tyrrhenian coast. Since these sites also appear as the most complex, building activity in this phase seems limited to these locations. Overall evidence (Vanzetti et al., 2014) would lead to the tentative placement of this phase in the RBA, although general chronology is primarily based on the more accurate stratigraphic sequences of sites in the central-western part of the island and a comparatively long-lasting cultural vitality of Nuragic groups in the East coast has been suggested at the few sites that yielded stratigraphic data (Salis, 2016), so the early FBA cannot be entirely excluded. In Ogliastra, the distribution of basalt appears coincident with the finds of oxhide ingot fragments, metalworking sites, and monumental sites related to water, such as S’Arcu ‘e is Forros – Villa-grande Strisai, Perda’ e Forri - Lanusei, and Cuguddadas - Cardedu (Archeosystem, 1990). This fits the known earliest phase for several sacred wells across the island (Salis, 2018) and the overall record of Cypriot items and ingots (Jones, 2007; Sabatini & Lo Schiavo, 2020), further reinforcing the chronological placement in the RBA for the use of basalt in Sarrala.

The distribution of basalt only south of the source is consistent with a long-distance already hypothesized counterclockwise circum-Tyrrhenian route (Lai, 2013). Since it seems reasonable that if the naval capability were present, the demand for basalt would have been met at the north of the source as well, such a pattern indicates that there was no local involvement in this transport, meaning that either group from overseas or from other areas of Sardinia could have been the vectors.

The critical point is that at least three of the four nuraghes exhibiting basalt (phase IV) in the latest phase also show archaic architectural solutions (phase I). This correspondence suggests an underlying, long-lasting ordering principle and quality inherent to those places, which we argue consists in their role in the early history of the area’s settlement and the charge they embodied as meaning and memory anchors for the descendants, still powerful and effective at the end of the Bronze Age, in line with the house-society model and the role of patrilineal lineage (González-Ruibal & Ruiz-Gálvez, 2016; Perra, 2021).

Even though unlikely, without excavation, building stratigraphy alone cannot exclude an alternative hypothesis, that of a parallel chronology for phases III and IV. While this changes the amount of labor investment through time, it still implies special, unequal ties to the agents bringing basalt (and likely metal). In turn, this would reflect a special status for those few nuraghes, which does not affect the argument relative to their more intense symbolic power than all other nuraghes.
Elements of the survey data from the area, which include those already summarized (Lai, 2013) with updates, amendments, and the addition of those recorded and studied later (Crispu, 2013), have been compared with an initial random sample of previously available data (Table 1), to gain insights into the degree of competition, (in)equality, and power-sharing across different areas. The entire study area of 28 km$^2$ holds 28 nuraghes, 15 giants’ tombs, two wells, and 16 villages, including those countable for being observable or recorded in past works (Cannas, 1964). The density of nuraghes is 1.00/km$^2$, a ratio found mainly in Northwestern Sardinia and not recorded in the entire Eastern half of the island except Lodine. The proportion of complex nuraghes out of the total varies: even keeping a conservative estimate of 15 ascertained complex nuraghes, the proportion amounts to 53.6%, definitely higher than the average calculated in the mid-1980s for the entire island (Lilliu, 1988a) and among the highest recorded (Webster, 1996a, p. 131, Table 5).

Additionally, the ratio of burials vs nuraghes was calculated and examined comparatively, following Webster’s seminal reasoning (Webster, 1996a, pp. 143–144). Among the limitations, there is a possibility that some giants’ tombs were connected to villages that have now disappeared. However, the differential preservation potential of tombs vs nuraghes is much higher than the one between tombs and villages since both tombs and villages tend to be similarly more prone to destruction for farming activities than nuraghes. Additionally, surveys initially considered for comparative purposes are necessarily uneven regarding methodological protocols and research goals but utilize broadly shared concepts in classifying site types. Moreover, as highlighted previously (Crispu et al., 2011), this case study supports the hypothesis that large numbers of giants’ tombs have disappeared relatively recently. This has implications for the attempts to reconstruct past landscapes and settlement patterns only based on recent surveys and highlights the importance of early sources to be ideally extended toward archival research and a close relationship with local informants. The 14 tombs recorded in 1964 (plus one likely burial cave, and excluding two more tombs to be verified), compared with the 28 nuraghes, and the general higher probability that a number of them have disappeared in the three millennia before the 1900s, support the hypothesis of a typical, canonical Nuragic locale, or habitation unit, as made up by nuraghe + burial (Blake, 2001). Variations or substitutions to the model include burial caves instead of giants’ tombs and a limited number of villages without, rather than around, nuraghes.

The tomb:nuraghe ratio recorded in Sarrala (1.9) is in line with the ratio recorded elsewhere in the eastern region of Ogliastra (Archeosystem, 1990; Castoldi, 2010) and to the territory near Senorbì (Dessì, 2005) (Figure 6); it appears slightly lower than the areas near Mara, Borore, Sedilo, and Norbello (Depalmas, 1998; Trump, 1990; Usai, 2003; Webster, 1991), much lower than several other sample areas (Table 1), with extreme values in Codrongianos, in the Marmilla area (references in Webster, 1996a,b, pp. 143–144), and especially in the central western lowlands near Solarussa (Usai, 2003), where very few tombs are identifiable, unlike nuraghes. Conversely, in the mountainous and steep areas of Esterzili (Bagella, 2007; Ortu, 1993) and Seulo (Puddu, 2012; Skeates, Gradolì, & Beckett, 2013) even lower ratios are recorded, possibly due to the low density of nuraghes in the former, and to the same reason and the presence of several cave burials in the latter. Regardless of the situation between the second and first millennium BC, in light of the largely underestimated consideration of natural caves as burial options in Nuragic times (Lai, 2021a), an area remarkably poorer in caves as Sarrala could also have had giants’ tombs in higher numbers due to the lack of available natural alternatives. As a general point, this contrasts with the hypothesis that each grave was used by the inhabitants of different settlement sites or habitation units and that not everyone had equal burial rights in giants’ tombs (Blake, 2002, p. 121; Webster, 1996a, pp. 104, 143–145). To our knowledge, no studies comprehensively address this aspect, which could be a new tool to highlight regional variation across the island reliably.

Focusing on these two territorial indexes (percent of complex nuraghes out of the total and nuraghes:tomb ratio), it is possible to recognize specific patterns between areas of the island and similarities that, in many cases, appear to align along geographic areas (Figure 6). Whether this is due to social and settlement dynamics or to analogous preservation factors, is to be ascertained with specific research programs; probably both elements are effectively shaping in complex ways the archaeological record of today. Ogliastra consistently has a greater-than-average proportion of complex nuraghes and a greater-than-average number of tombs per nuraghe combined (Archeosystem, 1990; Castoldì, 2010). Other extremes are represented by the Marmilla (Badas, Atzeni, Comella, & Lilliu, 1988), the Northwestern sample areas (Depalmas, 1998; Moravetti, 1992; Usai, 2003; Vidili, 2009), and the area near Silius, in Central-Southern Sardinia (Forci, 2008), with few complex
Table 1: Numbers and indexes relating to the proportion of complex nuraghes and tomb sites out of total nuraghes for a sample of surveyed regions of Sardinia (tomb sites include ascertained or likely burial caves)

<table>
<thead>
<tr>
<th>Area/municipality</th>
<th>Complex nuraghes</th>
<th>Total nuraghes</th>
<th>Total burial sites</th>
<th>Nuraghes: tombs</th>
<th>Percent complex</th>
<th>Percent of tombs out of total (nuraghes + tombs)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertenia area</td>
<td>76</td>
<td>43</td>
<td>1.91</td>
<td>31.71</td>
<td>34.40</td>
<td>(Crispu, 2013)</td>
<td></td>
</tr>
<tr>
<td>Sarrala, Tertenia</td>
<td>15</td>
<td>28</td>
<td>15</td>
<td>1.87</td>
<td>53.57</td>
<td>34.88 (Crispu, 2013); this study</td>
<td></td>
</tr>
<tr>
<td>Lanusei</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>1.20</td>
<td>83.33</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Tortoli</td>
<td>14</td>
<td>9</td>
<td>4</td>
<td>1.56</td>
<td>50.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Ilbono</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>2.50</td>
<td>60.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Lotzorai</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2.50</td>
<td>40.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Girasole</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Loceri</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>5.00</td>
<td>60.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Bari’ Sardo</td>
<td>14</td>
<td>4</td>
<td>2</td>
<td>3.00</td>
<td>50.00</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Cardedu</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>4.00</td>
<td>16.67</td>
<td>(Archeosystem, 1990; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Perdasdefogu</td>
<td>2</td>
<td>12</td>
<td>3</td>
<td>4.00</td>
<td>20.00</td>
<td>(Bartolo, Carta, Lecis, Prasciolo, &amp; Zanda, 1998; Castoldi, 2010)</td>
<td></td>
</tr>
<tr>
<td>Ogliastra total</td>
<td></td>
<td>158</td>
<td>73</td>
<td>2.25</td>
<td>42.07</td>
<td>30.80 (Bagella, 2007)</td>
<td></td>
</tr>
<tr>
<td>Codrongianos</td>
<td>21</td>
<td>1</td>
<td>1</td>
<td>21.00</td>
<td>4.55</td>
<td>(Basoli &amp; Foschi Nieddu, 1991) after (Webster, 1996a)</td>
<td></td>
</tr>
<tr>
<td>Monte Acuto</td>
<td>290</td>
<td>35</td>
<td>8.29</td>
<td></td>
<td>10.77</td>
<td>(Trump, 1990)</td>
<td></td>
</tr>
<tr>
<td>Bonu Ighinu valley</td>
<td>1</td>
<td>13</td>
<td>6</td>
<td>2.17</td>
<td>7.69</td>
<td>31.58 (Moravetti, 1992) after (Webster, 1996a)</td>
<td></td>
</tr>
<tr>
<td>Marghine Planargia</td>
<td>379</td>
<td>96</td>
<td>3.95</td>
<td></td>
<td>20.21</td>
<td>(Webster, 1991)</td>
<td></td>
</tr>
<tr>
<td>Borore</td>
<td>3</td>
<td>41</td>
<td>12</td>
<td>3.42</td>
<td>7.32</td>
<td>22.64 (Depalmis, 1998)</td>
<td></td>
</tr>
<tr>
<td>Area A (Sedilo and surrounding)</td>
<td>146</td>
<td>31</td>
<td>4.71</td>
<td></td>
<td>10.96</td>
<td>(Depalmis, 1998)</td>
<td></td>
</tr>
<tr>
<td>Area B (Sedilo and surrounding)</td>
<td>61</td>
<td>7</td>
<td>8.71</td>
<td></td>
<td>10.29</td>
<td>(Depalmis, 1998)</td>
<td></td>
</tr>
<tr>
<td>Aidomaggiore</td>
<td>4</td>
<td>62</td>
<td>36</td>
<td>1.72</td>
<td>6.45</td>
<td>36.73 (Vidili, 2009)</td>
<td></td>
</tr>
<tr>
<td>Norbello and surrounding</td>
<td>8</td>
<td>76</td>
<td>25</td>
<td>3.04</td>
<td>10.53</td>
<td>(Usai, 2003)</td>
<td></td>
</tr>
<tr>
<td>Solarussa and surrounding</td>
<td>29</td>
<td>29</td>
<td>1</td>
<td>29.00</td>
<td>55.17</td>
<td>(Usai, 2003)</td>
<td></td>
</tr>
<tr>
<td>Region Meana Sardo/</td>
<td>15</td>
<td>15</td>
<td>1</td>
<td>15.00</td>
<td>33.33</td>
<td>(Perra, 2008)</td>
<td></td>
</tr>
<tr>
<td>Laconi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Pfeddersheim, 2008)</td>
<td></td>
</tr>
<tr>
<td>PratÌ Muru Orroli</td>
<td>27</td>
<td>79</td>
<td>8</td>
<td>9.88</td>
<td>34.18</td>
<td>9.20 (Puddu, 2012; Skeates et al., 2013)</td>
<td></td>
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<tr>
<td>Seulo</td>
<td>0</td>
<td>3</td>
<td>9</td>
<td>0.33</td>
<td>0.00</td>
<td>75.00 (Ortu, 1993)</td>
<td></td>
</tr>
<tr>
<td>Esterzilli</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0.00</td>
<td>66.67</td>
<td>(Badas et al., 1988) after (Webster, 1996a)</td>
<td></td>
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<tr>
<td>Marmilla</td>
<td>43</td>
<td>269</td>
<td>10</td>
<td>26.90</td>
<td>15.99</td>
<td>(Forti, 2008)</td>
<td></td>
</tr>
<tr>
<td>Silius and surrounding</td>
<td>3–7</td>
<td>34</td>
<td>4</td>
<td>8.50</td>
<td>8.82</td>
<td>10.53 (Depali, 2005)</td>
<td></td>
</tr>
<tr>
<td>Senorbi</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>2.00</td>
<td>10.00</td>
<td>(Depali, 2005)</td>
<td></td>
</tr>
<tr>
<td>Decimoputzu</td>
<td>17</td>
<td>15</td>
<td>1</td>
<td>5.67</td>
<td>15.00</td>
<td>(Depali, 2005)</td>
<td></td>
</tr>
<tr>
<td>S. Antico island</td>
<td>10</td>
<td>53</td>
<td>9</td>
<td>5.89</td>
<td>18.87</td>
<td>(Depali, 2005)</td>
<td></td>
</tr>
<tr>
<td>Teulada</td>
<td>15</td>
<td>48</td>
<td>7</td>
<td>6.86</td>
<td>31.25</td>
<td>(Depali, 2005)</td>
<td></td>
</tr>
</tbody>
</table>

Reading Settlement Patterns in Bronze Age Sarrala, Sardinia
nuraghes and their difference consisting in the index burials/(nuraghes + tombs), which varies from less than 5% to over 35%. The Western lowlands near Solarussa (Usai, 2003) are characterized by a greater proportion of complex nuraghes coupled with fewer tombs per nuraghe. Outliers appear to be the territory of Seulo (Puddu, 2012; Skeates et al., 2013) and Esterzili (Ortu, 1993), where no complex nuraghes are recorded and the highest ratios of burial sites per nuraghe, with the anomaly, for Seulo, of burial sites mainly represented by caves. The indexes for the territory of Lanusei (Archeosystem, 1990; Castoldi, 2010), extreme for both proportion of complex nuraghes and tombs per nuraghe, might derive from random effects of the small numbers based on a situation similar to the rest of Ogliastra.

As concerns water-related ceremonial sites, although the excavation of a modern well near Nur. Su Tettìioni, in the mid-1900s, was reported to have intercepted an ancient well that yielded Nuragic hoe weights (Cannas, 1964; Crispu, 2013, p. 297), the well of Sa Brecca is the only one investigated in the area of
study (Basoli & Crispu, 2012). Its sheer size and complexity, involving using three different kinds of stones, one of the longest staircases recorded, and the complex surrounding spaces, make it a likely focus of ceremonial and political activity following the building, besides showing continuous later occupation through Roman and Medieval times.

6 Isotopic Data

Stable isotopes are natural variants of the same element found in the environment in specific ratios and are passed on through the food chain with predictable patterns. Their measurement enables the estimation of different categories of foods incorporated in an organism’s tissues and, therefore, has been used for decades to trace essential shifts in the human diet. Their effectiveness is admittedly better when dealing with very distinct foods (C3 vs C4 plants; marine vs terrestrial environments), whereas for the relative proportion of plant foods vs animal foods, as in most of Mediterranean prehistory, only a firm control over the baseline allows a reliable estimate. More recently, stable isotopes of animal and plant remains have been used to assess economic practices, specifically irrigation, manuring, and the differential management of different livestock species. One among the unique features of stable isotopic analyses is that of estimating the place within the food chain of single individuals so that paleonutrition and paleoecology can overcome the collective nature of faunal and botanical assemblages.

Concerning stable isotopes on humans, initial data are available within Nuragic proper – late MBA and EIA contexts (Atzeni et al., 2012; Lai, 2018; Lai, Fonzo, Pacciani, & O’Connell, 2014; Lai, O’Connell, & Robb, 2020; Lai et al., 2014; Wilkens, Zedda, Floris, Lai, & Ucchesu, 2015) and the earlier EBA through early MBA (Floris et al., 2013; Lai et al., 2005, 2007; Lai, 2008; Lai, Beckett, Medda, Goddard, & Hollander, 2021). Some broad trends have been identified and can be used to provide different perspectives helpful to build a model for spatial and social fields of practice concerning interaction at different scales. One such element is the intra-group δ15N standard deviation in humans. This indicator reflects mainly the protein portion of the diet and is the best marker of trophic level. Whereas the general lack of animal remains in association with human remains prevents accurate calculation of their interval and estimation of animal proteins, δ15N standard deviation provides an independent measure of dietary diversity and unequal access to animal foods. The overall trend recorded is a decrease in such diversity after the EBA and an increase again in the FBA-EIA (Floris et al., 2013; Lai et al., 2021; Lai et al., 2014; Wilkens et al., 2015). Furthermore, based on the current dataset, enriched δ15N values and greater standard deviation tend to characterize sites closer to the coast and in areas with lower rainfall (Lai et al., 2014, 2020). The limitation of such data is in the possible correlation of these factors: the pattern may not only be an indication of dietary diversity affected by proximity and familiarity with the sea as a source of food but also be a product of synchronic, spatial climatic variability and diachronic variability due to changes in economic practices and possibly of contacts with outside groups. However, this does fit well the overall reconstruction of a pioneering phase of high mobility hinging on extensive pastoralism and, therefore, isotopic variability deriving from pasture (EBA), followed by a transition toward an increasingly sedentary and integrated structure as spaces for livestock become reduced (MBA-RBA), with the institutionalization of collective rituals and values. Finally, contacts with outsiders, conflict, the concentration of management roles, and possible resettlement led to social and dietary variation in each community becoming wider (FBA-EIA). Local histories, of course, must have represented cases aligned, or at times divergent from, such overall trends.

Regarding stable isotopes of faunal remains, the only available data as proxies for animal management in Nuragic times are from Nuraghe Arrubiu (Lai, Fonzo, & O’Connell, 2017). Values are compatible with extensive, generalized control identifiable from the relatively small variation in the different species’ averages, especially in the MBA-RBA, in sharp contrast to patterns documented at early Copper Age sites (Lai, 2011, 2017). Cattle appear distinct in two groups, one for meat, one likely tamed for plowing, unlike in Bell Beaker-EBA groups where evidence for such a binary distribution has not been detected. More controlled management of sheep/goats in the FBA-EIA phase (inferred based on higher δ15N and lower standard deviation) points to more specialized exploitation of secondary products, to be identified in wool, but possibly also in more intense and
7 Archaeogenetic Data

The use of modern DNA to infer past migrations is now well established, but control over time has proven problematic since the timing of cultural interaction is not constant. The advances in extraction and analysis of ancient genetic material (aDNA) have recently brought archaeogenetics to the forefront of bioarchaeological practice and theory, bypassing these problems. The power of archaeogenetics in quantitatively tracking gene flow, genetic drift, and, therefore, migration, mobile vs. sedentary patterns, and all sorts of related phenomena is so revolutionary that some scholars claim it to be a turning point for a new archaeological paradigm. Further specific aspects that can be explored through archaeogenetics are gender roles and marriage patterns, as far as they are related to biology, by the distinction of mitochondrial and nuclear DNA and their asymmetrical variation. Its limitations, besides the practical ones due to preservation and cost, are in the overestimation regarding the inference of cultural phenomena involving meaning, identity, and diffusion of ideas, all aspects that need the consideration of material culture markers together with all available evidence.

In regards to Sardinia in the Bronze Age, aDNA in the last several years has provided new evidence regarding several aspects essential for a deeper exploration of social organization and scales of interaction: (a) the question of the origin of the human groups that around the eighteenth to seventeenth century BC began the monumental phase known as Nuragic; (b) gender dynamics in the settlement and relationships between groups; and (c) the role of immigration to explain cultural and social changes in the Nuragic world.

a) Based on changes in material culture, it has been suggested that the Bell Beaker period may have represented a time of heightened mobility and possibly substantial immigration into Sardinia (Lilliu, 1988b). The limited morphometric data also appear to be compatible with the inference of some inflow of outsiders, sufficient to modify morphometric traits (D’Amore, Di Marco, Floris, Pacciani, & Sanna, 2010; Lai, 2021b). Genetic evidence currently does not support nor disprove this possibility, mainly because the potential areas of origin for such intensified contacts and relationships—along routes from Iberia, Southern France, Corsica, North Africa, and Sicily—are demonstrably or likely to have had a relatively similar genetic makeup up until the Bronze Age. For Sicily, the limited evidence for the Bronze Age includes a relevant frequency of the r1b1 haplogroup in males on the Western side of the island (Fernandes et al., 2020), which matches its frequency in Bronze Age central-southern Sardinia, in contrast with Northwestern Sardinia, where macro-haplogroups G2a2 and I2 appear dominant. Trace of the possible Iberian link can be found in male haplogroups R1b-V88 and I2-M223, prevalent in Neolithic Iberia (Marcus et al., 2020), and in one mitogenome from Copper Age Iberia, which is today Sardinian-specific (Olivieri et al., 2017). However, it is presently impossible to clarify whether connections were direct, or through the Balearic Islands, or via Tunisia and Sicily, or a combination. Considering the genetic similarity of Neolithic Sardinia, Iberia, and Southern France, immigration, even of substantial magnitude, from those locations may go undetected until targeted more precisely. Additional evidence for links during the foundational Bell Beaker period is one individual of North African ancestry and one of likely Eastern ancestry (Fernandes et al., 2020), which provide clues to the intense interconnections recently also shown by the provenance of ivory items at the site of Padru Jossu (Morillo León, Pau, & Guilaine, 2018), which turned out to be from both African and Asian elephants.

b) The data concerning the distribution of haplogroups are essential to have independent evidence about social phenomena such as the possible sex-biased original third millennium BC immigration and the existence of gender-based descent reckoning and residence patterns. Patrilocality, already proposed together with polygyny and a pastoral ideology based on space arrangements and ethnographic comparisons (Webster, 1996a, p. 127), appears supported by location-based clusters of Y-chromosome haplogroup frequency at sites dating to between the Bell Beaker-EBa (Su Crucifissu Mannu; perhaps individuals from...
Anghelu Ruju) through the later Bronze and Iron Age (Seulo cave sites; s’Orcu ‘e Tueri) (Marcus et al., 2020).
At each of these sites, over half of all analyzed males belong to the same macro-haplogroup, unlike females whose haplogroup frequency is more diverse within each group but less different across groups. Additionally, these female haplogroups essentially correspond to those documented in Neolithic mainland Europe. On a larger scale, more diverse female haplogroup frequencies have also been detected in modern Sardinian populations (Chiang et al., 2018), pointing to a comparatively more recent male ancestry on the island, interpreted as deriving from different dynamics, such as polygyny – already suggested on other lines of evidence (Webster, 2016, p. 109), patrilineal descent reckoning, inter-generational transmission of reproductive success through differential wealth and power (Heyer et al., 2015), or a likely combination, in line with increasing evidence from Bronze Age across Europe (Goldberg, Günther, Rosenberg, & Jakobsson, 2017). The presence in the mountainous Seulo groups of Steppe-related haplogroup r1b1 (Marcus et al., 2020), as in Bronze Age Sicily at Grotta Buffa (Fernandes et al., 2020), suggests immigration of groups that were already in contact with these newcomers to Western Europe.

c) A critical conclusion shared by these recent studies is that even though individuals of different ancestry are recorded, even possibly from far away areas, there is no trace of substantial gene flow until Phoenician presence on the island, which would indicate contacts but no large-scale immigration until then, and a considerable population continuity due to genetic isolation (Chiang et al., 2018; Fernandes et al., 2020; Marcus et al., 2020; Olivieri et al., 2017).

8 Paleoclimatic Data

Unlike stable isotopes and archaeogenetics, paleoclimatology is a broader field of study encompassing many methods, proxies, and materials for ancient climate reconstruction, including deep sea cores, magnetism, and palynology. In this case, a delay in research deeply affects the knowledge of ancient climates in Sardinia. The first reliable pollen analyses from accurately dated contexts are relatively recent, and similar lag can be cited for sedimentology, geomorphology, and so on. Climate dynamics recorded in the surrounding Mediterranean region are helpful despite their limitation in potentially reflecting microclimate and specific environmental conditions that depend on human practices.

Environmental stress as a factor in Nuragic cultural change at the end of the Bronze Age has been previously related to agricultural activities, intensification, and the effect of population growth on drought-prone regions such as the Mediterranean (Basoli & Foschi Nieddu, 1991; Ialongo, 2018). A direct impact of climate change has been occasionally mentioned as a potential factor in affecting environmental balance or even triggering cultural change at the end of the Bronze Age in general (Webster, 1996a), more rarely concerning specific sites (Nieddu et al., 2016; Usai et al., 2011). The paleoclimatic history of Sardinia in the Bronze and Iron Ages has only recently been investigated directly. Outdated studies have a minimal chronological resolution (Serra, 1980), or they had signs of a clear human impact, making them more relevant to local environmental conditions than to broader trends (Cali, Lentini, & Palmieri, 1993; Fedele, 1979, 1980; Palmieri & Lentini, 1994). Among the few late Holocene paleoenvironmental sequences recently produced at sites in Sardinia, in the case of Sa Curcurica, eastern Sardinia, lack of chronological resolution does not help identify meaningful phases of change at scales parallel to that of Bronze Age cultural data (Beffa et al., 2016), whereas at Lake Baratz, in the area of several major Bronze-Iron Age sites in the vicinity of Alghero, tighter chronology allows us to place in the 2000–1400 BC range the presence of forests of evergreen oak, olive trees, and lentisk/terebinth, and the first record of chestnut pollen on Sardinia (Pedrotta et al., 2021); unfortunately, the sharp reduction in arboreal pollen in the following period cannot be accurately tied to any specific cultural phase. The most relevant pollen record, indicative mostly of human intervention on the landscape, comes from Nuraghe Arrubiu, Orrroli (Lopez, Lopez Saez, & Macias, 2005), where the initial, foundational phase of the settlement in the MBA3 appears to reflect a densely forested surrounding, which is cleared for cultivation in the following phase. The site was virtually abandoned during the FBA, and village life in the Iron Age gravitates instead around the area of the well, Su Putzu (Campus et al., 2008; Lo Schiavo, 2003), ca. 1 km
away. Besides the collapse of the structure, this could also be related to a change in water availability where the nuraghe was built, which in turn derived from a change in rainfall. Especially in plateau areas, the water table is sensitive to slight variations. In any case, the 3.2 kya event remains unrecognized in Sardinian cores.

Without chronologically fine-grained climatic reconstructions, a general outline of climate change can be inferred following an analogic process based on data from the surrounding Western Mediterranean, as has been suggested (Webster, 1996a, p. 42) and later attempted more deliberately (Lai, 2009). The importance of microclimates remains, but the existence of generalized changes over vast areas is also undeniable, making it profitable to use data from North Africa, Sicily, the Italian peninsula, the Ionian area, the Iberian Peninsula, Southern France, Corsica, and the Balearics, concerning the magnitude and nature of climate change accompanying the trajectory of the Nuragic society.

Climate change was likely one of the elements marking the start of the continuous trajectory of the human groups that have inhabited Sardinia from the Bronze Age to today. The RCC named 4.2 kya event, recognized widely in the Near East and recently also in the West (Drysdale et al., 2006), corresponds to a sharp break in the cultural history of the island, with the complete disappearance of Monte Claro material aspects, settlement patterns, and traditions of doing things. Whereas the magnitude, nature, and local effects are still debated, the existence and relevance of this event across the Mediterranean are not in question. It seems that it may have created the conditions for Sardinia to be deeply permeated by Bell Beaker cultural traits, which then drifted away from the more international models (Atzeni, 1996; Drudi, 2023).

As far as the long centuries of development during the whole Nuragic MBA and the LBA, a warm and relatively dry period has been recorded (Ellwood et al., 2001; Giraudi, 2004; Magny, Miramont, & Sivan, 2002; Sadori & Narcisi, 2001; Tuccimei et al., 2003), whereas the first half of the first millennium BC appears cooler and rainier, at least in the northwestern regions of Sardinia, in agreement with the data collected in temperate Europe that led to the identification of the Sub-Atlantic phase. However, several case studies in Northern Africa, Southern Spain, and Sicily point to a brief arid phase, apparently correlated (whether directly or inversely) with similar trends in the different regions documented around the first centuries of the first millennium BC (Carrión, Andrade, Bennett, Navarro, & Munuera, 2001; Carrión, Munuera, Dupré, & Andrade, 2001; Giraudi, 2004, pp. 540–542; Lamb et al., 1995; Magny et al., 2002; Watson, 1996). In general, a period of climate instability seems to have begun between the end of the second and the beginning of the first millennium BC (Emeis et al., 2000; Giraudi, 2004), dates which may well correspond to the arid phase discussed above, despite the approximate chronology currently available, and are compatible with RCC much better documented in the Eastern Mediterranean where the 3.2 kya event has been securely identified (Kaniewski, Guiot, & Van Campo, 2015; Kaniiewski et al., 2011, 2013), and considered by many as the initial phenomenon setting in motion the crisis of the LBA interconnected Mediterranean. Whether the prevalent aspect was instability or outright drought may depend on the areas, but the effect must have been a different combination of poorer and less consistent harvests and of actual disruptive changes in hydrology, especially in areas dependent on small watersheds for springs needed both for human domestic use and for animal drinking. This had the potential to force a change in habits or, in extreme cases, even the complete relocation of certain groups.

9 Discussion

The elements introduced above, used as interpretive tools to read the specific human landscape in Sarrala, enable us to draw a scenario of spheres of interaction intersecting at different scales and to suggest their evolution over time in ways broadly parallel to general developments across the island but with some degree of specificity to the area. A dynamic history of the local social and organizational structure and the demographic, economic, and relational phenomena is outlined by reading the settlement patterns recorded on the ground in light of the initial data available from stable isotopes, archaeogenetics, and paleoclimatology. Site-specific, fine-grained isotopic, genetic, and climatic data are unavailable and unlikely to be available due to preservation. However, from a methodological standpoint, this approach is potentially applicable for the analysis of other regions of Sardinia in the Nuragic Bronze Age.
There is no evidence of human presence in the Sarrala area during the Bell Beaker and EBA phases. However, a complete absence seems unlikely, and if we admit a very dispersed presence over the entire island, it is possible that this territory land was devoid of stable settlements but only frequented seasonally by pastoral groups based in bordering territories as the larger valley to the West or the coastal areas to the North and South. The overall distribution of nuraghes appears compatible with fairly rational, efficient exploitation of the available territory derived from early centers (phase I in Sarrala, tentatively Sardinian MBA-early RBA), quite regularly distanced from one another, as would be expected from consecutive exploitation of the available territory derived from early centers (phase I in Sarrala, tentatively Sardinian or planned exploitation projects, as modeled in previous works (Ialongo, 2018; Shennan, 1993). The very identity of males in a typically binary pattern that became dominant across Europe in the Bronze Age, suggested by stable isotopes elsewhere on the island must have been a culturally characterizing element, tied to land was occupied and presumably turned into farmland and pasture. The prevalence of pastoralism suggested by stable isotopes elsewhere on the island must have been a culturally characterizing element, tied to farming to feed a growing population, may have caused a crisis in the traditional extensive management of the herds, which could not only generate opportunities for cooperation but also for conflict. Unlike areas where multiple collective tombs are documented at a minority of sites, the tomb:nuraghe ratio in Sarrala could be a sign of development toward autonomous identities within the broader ancestral affiliation. The ratio of the complex:simple nuraghes can also be interpreted similarly as the correlate of autonomous entities engaging in peer–polity interaction dynamics within a larger lineage community, to be understood in fractal levels.

Sarrala Phases III and IV represent the differentiation of some sites, with the emergence of complex nuraghe. Of course, only excavation at each site in Sarrala could, in principle, help establish the degree to which phase II and phase III/IV were contemporary since evidence from Nuraghe Arrubiu (Cossu et al., 2003) proves that some complex nuraghes have been planned as such, and distinct construction phases may have been structural rather than temporally spaced. There is no excavation-derived evidence to establish whether and where phases III and IV – with or without the presence of basalt in the masonry – could have overlapped. However, wall stratigraphy at Nur. Anastasi provides the evidence to distinguish them: at this site, an addition to central tower C pre-dating the use of basalt wedges is recorded. This suggests the proposed chronological differentiation.

Accepting that basalt is to be taken as a chronological marker of a distinct, latest chronological period, the inference is that of concentration of labor availability/mobilization at a small number of sites, which could be aligned with the overall pattern of abandonment of the majority of nuraghes in most areas of Sardinia (Campus, Leonelli, & Lo Schiavo, 2010; Depalmas, 2009a, 2015; Ialongo, 2018; Perra, 2009, 2011, 2018d; Usai, 2018). This preceded or coincided with, the time of seaborne contacts as reflected in the presence of painted Eastern pottery and metal island-wide, to which we can locally add basalt. This phase, in general, is dated through cross-comparisons to the late RBA-early FBA (Sabatini & Lo Schiavo, 2020) or the thirteenth to early twelfth century BC.

Regardless of the fact that some of the complex nuraghes could have been contemporary, the pattern implies that only some groups had the relationships and the rights of interaction, with outsiders providing copper and basalt as a trade byproduct. Since the sites with basalt also happen to be those with archaic features, and they seem pretty evenly spaced across the whole area, they match the pattern expected according to “house-society” dynamics Levi Strauss sensu (González-Ruibal & Ruiz-Gálvez, 2016): those are
ancestral locations where the founding lineages had resided the longest, whereas the smaller nuraghes and those with no basalt would represent the residence of collateral patrilineal branches, more distantly related to the first settler(s). As such, they could have had some authority to diplomatically represent the tribe in relationships and negotiations with outsiders so that some groups would have preferential access to sea-borne goods reflected in non-local stone, which appears locally as a proxy for access to metal and possibly other items from the Eastern Mediterranean. An additional clue to a unique role is that the two sites with manifest archaic architectural solutions (therefore assigned to Phase I) are the only ones for which two giants’ tombs are recorded – although not all are preserved. This could reflect the need, over time, to split a portion of the inhabitants closer to the higher lineage from the commoners in times when there was no more available land for fission or rational exploitation or simply more intense demographic pressure on limited burial space, at sites with a more extended history of settlement and population growth.

The consequence of this framework for the exploration of scales of interaction is that we can define their varying levels of magnitude: the smallest sphere can be identified in the nuraghe-based group and territory to be understood as a patrilineal, descent-based, and house-based entity, which mirrors in a fractal way (González-Ruibal & Ruiz-Gálvez, 2016) the superordinate clan or tribe, similarly descent-based. Over 25 such units have been documented in the study area, each averaging ca. 1 km² of the surrounding territory, potentially each or most with their burial site, unlike the pattern recorded elsewhere (Badas et al., 1988; Campus, 2008; Usai, 2003).

At the polity level, corresponding with the study area of Sarrala, we reconstruct an unstable and periodically challenged authority centered on the early founders’ most direct patrilineal and patrilocal descendants. In practical terms, the interaction within this sphere between groups based on each nuraghe must have involved the shared use of water, both for daily domestic use and consumption by humans and livestock, since fewer springs were likely available than the total number of nuraghes (Crispu, 2013). Food-sharing must have been frequent and possibly followed the specific events of the micro-history of relationships between groups. In a patrilineal and polygynous society, wives must have been acquired from neighboring groups in early times as the EBA through the MBA. As genealogical distance increased, exogamy may have been looser, and wives may have been chosen from within the tribe, increasingly as part of alliance strategies while resources became more contested. Shared, common pasture must have been another critical opportunity for interaction; considering the likely open, extensive use of the landscape in EBA-MBA, as population growth and either spontaneous or planned fission subdivided space and necessitated larger plots to be farmed for grains, the conflict became likely more frequent, with multiple opportunities for alliances and rivalries to be created, negotiated, and modified. When a group branched out for the foundation of a new nuraghe during the MBA-RBA, the building activity itself must have been an opportunity for communal labor carried out by the whole descent group (Webster, 1991). Periodic ritual events must have created opportunities to strengthen common identity by retelling cosmological structures and ancestral histories. Among these events, fundamental must have been those at burials, which in Sarrala were fragmented across the many individual Nuragic locales – tower/tomb pairs (Blake, 2001).

A broader level of interaction is identified in contacts with neighboring groups beyond tribal territory and further within Sardinia. This is proven by the consistency and identity of material culture, both portable and architectural, across the island, which witnesses the intense exchange of know-how and maintaining a standard and shared technology, lifestyle, and value system – Lilliu’s “morality” (Lilliu, 1988a). Part of this was probably the movement and exchange of products, gifts, and people, including those most essential for a community’s survival: wives. Pasture needs may have required mutual help in bad years, which does not equate to regular transhumance (this could be detected in the future through stable isotopes). In Ogliastra, historically, some mountain communities had extensive transhumance routes and established winter pasture in the Southeast of Sardinia (Ortu, 1988; Pillai, 1999), whereas others, including Tertenia, controlled portions of land at different altitudes that allowed them not to practice long-distance transfers. Nor did any of the lowland communities need to transfer herds long-distance. Traditional transhumance in the area south of Sarrala (Quirra, Alussera), for instance, apparently began or was intensified, in particular historic circumstances, linked to a population vacuum created by war and epidemics in the fourteenth century (Cannas, 1997). This also shows how specific events can determine unique historical trajectories. Interaction with other descent-
reckoned groups likely involved peaceful relationships but also conflict over resources or more immaterial principles; some such conflicts may have involved armed raids and feuds (Webster, 1996b) in fractal alliance patterns similar to those described for the Nuer and Tiv (Sahlins, 1961).

As a third level of social interaction, beginning in the late fourteenth century BC, there is evidence of contact between Sardinia and the Eastern Mediterranean: the alabastron from Nur. Arrubiu (Lo Schiavo & Vagnetti, 1993), only 30 km west of Sarrala, appears to be the oldest Aegean sherd recorded in Sardinia and may have reached its destination through the now-infilled bay of Sarrabus, ca. 40 km south of the study area. These contacts, possibly mediated initially via Southern Italy (Russell, 2011), intensified as a preferential route of the islands connecting Sardinia to Sicily, the Peloponnese, Crete, and Cyprus. Local links to such long-distance routes are signaled at Nur. Anastasi by the presence of oxhide ingot fragments and painted pottery assigned to the LHIIIc (Basoli, 1980), both corresponding to the peak in the presence of eastern Mediterranean artifacts in Sardinia (Sabatini & Lo Schiavo, 2020; Spigno, 2022; Usai & Lo Schiavo, 2009), in the twelfth century BC. This constitutes the largest sphere of interaction that the area of Sarrala shows evidence for, which likely involved various forms of gift exchange and actual trade of products, not only with metal as the primary focus, but also pottery, blue glass beads, and basalt. Of course, it must have included perishable and consumable agropastoral items (Campus & Derudas, 2012; Perra, 2018a), such as cured meat, skins, wool, textiles, cheese, and wine. Besides evidence from pottery and its contents (Depalmas, Loi, Garnier, & Pecci, 2020; Perra, 2018a), the isotopically-traced availability of animal products at Bronze Age sites—whether direct or circumstantial—and the controlled grazing of caprines at FBA-EIA Nur. Arrubiu seems to support this. Some active roles may have developed in organizing joint ventures overseas and raids, also considering the more substantial presence of Sardinian pottery in the Western Mediterranean in the Iron Age. A change in the relationships between interior and coastal areas within Sardinia should also be considered, and isotopic evidence is compatible with such changes (Wilkins et al., 2015).

Around the twelfth century BC, the cultural and ceremonial landscape in Sarrala changed with the building or monumentalizing of the well at Sa Brecca (Basoli & Crispu, 2012), and likely at least another well near Nur. su Tettioni, ca. 1 km from Nur. Anastasi. We can assume that the same shift in ceremonial focus away from collective tombs and toward water-related cults recorded elsewhere had similar dynamics in Sarrala: the imposing new structure of Sa Brecca must have provided a new catalyst for ritual activity and new arenas for power struggles between higher-prestige lineages and secondary ones, with dynamics already well outlined elsewhere (Perra, 1997, 2021). If the dense presence of giants’ tombs was a trait specific to the area, as it seems, specific dynamics might have involved more resistance to give up the ancestral burial location. If, as we suggest, the density of tombs is partially a product of differential preservation relative to elsewhere in Sardinia, dynamics could be hypothesized to be less dissimilar.

Two points from the evidence recorded in Sarrala have broader relevance as contributions to general interpretations in the literature. One is the interpretation of sacred wells as federal sanctuaries in neutral lands or buffer zones (Ialongo, 2018), and the other is the chronology of sacred wells. As to the first, the impression is that the well at Sa Brecca, as imposing and monumental as it was, had mainly local significance. The architectural relevance of Nuragic wells at Cuguddadas to the North, Is Pirois to the South (Salvi, 2008), and the possible presence of the Nuragic spring at Funtanas to the West and another Nuragic well within Sarrala east of Nur. Anastasi (Crispu, 2015) points to the pertinence of the wells to a single tribe/lineage territory or part of it. On special occasions, of course, such locations likely served the need for participation of outsiders as guests, from bordering regions or even farther. Still, their primary social role was to be centers of social cohesion for local groups whose organization was changing due to population growth, lack of available land, and, therefore, conflict over resources (Ialongo, 2018; Perra, 2021; Webster, 1996a), which had a different pace in areas with not only differential productive potential but also with different local histories. As to the chronology of the well at Sa Brecca (Basoli & Crispu, 2012), the employment of basalt wedges in analogy with the enlargement of Nur. Anastasi, Barisoni, Longu, Marosini, and Baleri suggest placing its monumental structure in the same phase, possibly RBA-early FBA (the analysis of the ceramic repertoire has not been completed for a reliable assessment).

Finally, the paleoclimatic record outlined above can be used to address broader questions concerning the reasons and context for rising water-related ceremonial activity in Sarrala and across the island. Locally, the
drought and instability felt across the Mediterranean after ca. 1200–1150 BC had the likely effect of some water springs and wells drying up due to changes in the water table. Here we argue that the importance of water, already crucial in any agropastoral economy as the Nuragic one and already a catalyst to ritual activity since the RBA (Depalmas, 2018b; Salis, 2018; Webster, 2014), was magnified by climatic disturbance as hypothesized by several scholars (Depalmas, 2014) prompting ritual intensification and monumentalization at the sites where water was more reliable, consistent, and abundant. Additionally, if the ancestral spirits were to some degree considered to influence the living, their relative lack of power in affecting water availability may have been considered an additional cause for the shift away from giants’ tombs.

Practical problems deriving from reduced rainfall include decreased harvests, decreased biomass available for pasture, and the discontinuity in supply location for domestic use and for both humans and livestock to drink. This means, at the local scale, that extended polygynous units and their dependents who were used to having their supply closely available needed to gain access to other sources and negotiate use with those whose closest sources were not dry. For large herds, pasture and water may have required to also arrange the seasonal transfer of herds to the uplands, such as the plateaus beyond the Quirra River, to the West, known as Su Pranu, Tacchigeddu, Taccu Mannu, and possibly further, in areas west of Jerzu, Ulassai, and Osini. Such augmented need for mobility may be at the root of intensified hospitality during ceremonial occasions at the sacred wells, affecting political and organizational dynamics.

In this context of heightened social restructuring, the use of the symbolic power associated with metallurgy, which at roughly the same time in Cyprus even generated an ingot god (Sabatini, 2007), may have also been an instrument for leading lineages to establish or reinforce authority over the surrounding territory and human labor. In Sarrala, metallurgy, Eastern Mediterranean links, navigation, and water appear connected. At the same time, clues of differential potential for wealth and power accumulation and concentration and an economy that relies on pastoralism more than intensive cereal growing may be found in the high proportion of complex nuraghes out of the total. The poverty of agricultural land compared to areas like Marmilla or the Western lowlands may have provided fewer opportunities for inequality between descent groups, with wealth being more mobile in the form of herds rather than unmovable land and crops and with a weaker grip on dependent groups. This is not a surprising trend for mountainous areas, which ethnographically have provided fewer opportunities against existing leveling mechanisms despite the increasing scarcity of new land for a growing population, as in the RBA-FBA.

In the changes around the twelfth century BC, it appears that social dynamics that were developing due to population growth and fission (Ialongo, 2018) or planned expansion of the productive basis (Perra, 2021) came to close chronological proximity or overlap with intensified contacts with the Eastern Mediterranean and especially Cyprus, and with the 3.2 kya climatic event. Disentangling these three trajectories and identifying possible triggers is tied to the resolution of their temporal definition.

10 Conclusion

The research presented here details the result of the survey and mapping of sites that allowed the reconstruction of the local settlement history in the Sarrala area of Eastern Sardinia. Whereas specific patterns of differential preservation between nuraghes and giants’ tombs bias and limit our interpretation based on structures present today, different proportions of nuraghes and burial sites are considered to assess dynamics dealing with the branching out of settlements and its relationship with lineage-based societies.

New perspectives from stable isotopy, archaeogenetics, and paleoclimatology are used to understand contributing factors in interpreting such evidence. A society with a solid economic and symbolic component of pastoralism, rooted in the Bell Beaker and EBA patterns of significant animal product consumption, with extensive livestock raising even in MBA-RBA Nur. Arrubiu appears linked, as hypothesized in prior research, to patrilineal and patrilocal kinship organization, materialized in patterns compatible with the suggested house-society model. In understanding the history of the area and the whole Nuragic society, an essential element is also identified in climate, which provided the stability necessary for population growth and
proliferation of settlements. Around the twelfth century BC, the instability and unreliability of rainfall caused widespread settlement disruptions and reorganization across Sardinia.

A local history was reconstructed, with early rooting (Phase I), the proliferation of settlement (Phase II), enlargement and increase in complexity (Phase III/IV), with a final period of increased complexity associated with metallurgy, sea-borne exotics from the Eastern Mediterranean, and a focus on water-related ritual activity (Phase IV). This phase is characterized by a bundled occurrence of elements such as metallurgical activity, exotic items, and use of basalt in construction in the last phase at each site, which overlap with the sites with evidence for earliest settlement, marking the existence of a long-lasting authority tied to the lineages residing in the oldest ancestral locations.

The assessment of interactions and their changes over time was outlined based on the reconstruction of settlement, economy, and climate. From an economic basis essentially self-dependent in the EBA and MBA, where grazing needs and movement of wives provided the main opportunity for contacts over distances beyond the lineage-controlled territory, the progressive rooting in each patrilineally characterized tribal area, practices appear increasingly entangled in the framework of Mediterranean contacts, which, together with involvement in metal trade, also included, possibly as byproducts of long-distance contacts, fine pottery, wine, wool, and occasionally basalt. The rise of ceremonial activities within different polities not only became the new opportunity to maintain an island-wide common identity through the profound transformations that Nuragic society underwent in the transition to the FBA-EIA but also provided a new focus for the different groups that were displaced by changes in water availability, both in terms of meteoric and groundwater.

Research is expected to proceed in different directions. Local material culture has barely been examined, and large amounts of lithics and pottery from excavations from the 1960s to today still await basic analysis. A publication of the excavation contexts, stratigraphy, and graphic and photographic records is also long overdue. Furthermore, mapping and the landscape study should be carried out according to modern standards on sites that have been investigated and on those only minimally recorded. Basic zooarchaeology on excavated collections has not been carried out yet, which will also help assess the potential for biochemical analyses; geomorphology is also crucial in understanding the environment, especially in coastal areas that were likely affected by sea-level changes, infilling of coastal lagoons, and massive erosion and colluvium, already recognized episodically in the area.

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