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TAPHONOMY AND GENESIS OF SHELL LENSES: THE CERRO BANDURRIAS LOCALITY (TIERRA DEL FUEGO, ARGENTINA)

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Abstract. This paper presents the taphonomic and geoarchaeological study of a thin shell lens identified 3.2 km from the coast of San Sebastian Bay on the hilltop of the inland Cerro Bandurrias archaeological locality (Tierra del Fuego Province, Argentina). The biological assemblage of the shell lens comprises marine fauna (bivalves, gastropods, and fish) that may represent the remains of the occasional exploitation of littoral resources by hunter-gatherers. However, since the lack of unequivocal anthropogenic signals, alternative non-anthropogenic hypotheses need to be also assessed. Indeed, the time frame of the shell lens (radiocarbon dated as ~6500 cal. years BP) indicates that the bioclast accumulation occurred during the Middle Holocene marine transgression with a different paleogeography, when the hill was part of a coastal landform (peninsula). The methodological design comprised the combination of different and independent sources of information and the techniques applied to assess competing genetic hypotheses. Based on compositional, taphonomic and sedimentological analyses, our research suggests that the most parsimonious explanation is that hunter-gatherers were the primary agents of bioclast accumulation of the lens. Thus, this ephemeral archaeological evidence provides a new record for the human exploitation of littoral resources on the Atlantic coast of Isla Grande de Tierra del Fuego during the Middle Holocene. The conspicuous character of shells improves the archaeological visibility of short term, non-redundant past human occupations.

Key words. Archaeomalacology. Geoarchaeology. Actualistic taphonomy. Hunter-gatherers. Middle Holocene marine transgression. Coastal evolution. Littoral human occupations. Ephemeral archaeological record.

Resumen. TAFONOMÍA Y GÉNESIS DE LENTES DE VALVAS: LA LOCALIDAD CERRO BANDURRIAS (TIERRA DEL FUEGO, ARGENTINA). Este trabajo presenta el estudio tafonómico y geoarqueológico de una lente de valvas identificada a 3,2 km de la costa de la bahía San Sebastián en la cumbre de la localidad arqueológica Cerro Bandurrias (provincia de Tierra del Fuego, Argentina). El conjunto biológico está compuesto por fauna marina (bivalvos, gasterópodos y peces) y fue interpretado como los restos materiales de la explotación ocasional de recursos litorales realizada por cazadores-recolectores. Sin embargo, la ausencia de evidencia de origen antrópico inequívoca hizo necesario evaluar hipótesis alternativas que propongan una génesis no antrópica. El marco temporal dado por un fechado radiocarbónico de ~6500 años cal. AP indica que la acumulación de bioclastos ocurrió durante la Transgresión Marina del Holoceno medio con una paleogeografía diferente, cuando el cerro era parte de una geoforma costera (península). Aquí presentamos el diseño metodológico, que incluye una combinación de fuentes de información distintas e independientes para evaluar las hipótesis en competencia. En base a los análisis composicionales, tafonómicos y sedimentológicos, nuestra investigación sugiere que la explicación más parsimoniosa es que los cazadores-recolectores fueron los agentes principales de acumulación en la lente. Por lo tanto, esta evidencia arqueológica efímera provee un nuevo registro para la explotación humana de recursos litorales en la costa atlántica de la Isla Grande de Tierra del Fuego durante el Holoceno medio. El carácter conspicuo de las valvas aumenta la visibilidad arqueológica de ocupaciones humanas breves y no redundantes.

Palabras clave. Arqueomalacología. Geoarqueología. Tafonomía actualista. Cazadores-recolectores. Transgresión marina del Holoceno medio. Evolución costera. Ocupaciones humanas litorales. Registro arqueológico efímero.

SHELL MOUNDS, beds, and lenses are widespread features of the fossil record. Several taphonomic and archaeological models based on contemporary observations and ancient deposits have been developed to explain the genesis of these bioclastic concentrations (*e.g.*, Meehan, 1975; Claassen, 1991, 2000; Kidwell & Holland, 1991; Stein, 1992;

Kowalewski *et al.*, 1994; Orquera & Piana, 2000, 2001; Kowalewski & LaBarbera, 2004; Favier Dubois & Borella, 2007; Briz Godino *et al.*, 2011; Hammond, 2015; Zangrando *et al.*, 2020; Gomes Rodrigues *et al.*, 2024). Depending on their origin, the study of marine shell-rich deposits may provide information about ocean life and ecosystems, landscape evolution and environmental change, or insights into past human-sea relationships (*e.g.*, Martínez *et al.*, 2006; Zanchetta *et al.*, 2012; Bjerk *et al.*, 2016). Therefore, once these deposits are identified, methodological tools are applied to describe and interpret the meaning of shell accumulations according to disciplinary goals and interests (*e.g.*, Meldahl, 1993; Claasen, 1998; Kowalewski, 2002). Regardless of the field of study, taphonomy proved to be key to critically assessing the pool of agents and processes involved in shell accumulation (*e.g.*, Kidwell *et al.*, 1986; Kidwell & Holland, 1991; Gutiérrez Zugasti, 2008–2009; Hammond, 2014; Beovide & Martínez, 2020).

However, there are cases in which the natural or cultural genesis of shell accumulation is not self-evident. Hence, these ambiguous deposits pose a crossroads for paleontological, geological, and archaeological research that requires further assessment (*e.g.*, Attenbrow, 1992; Henderson *et al.*, 2002; Beovide *et al.*, 2015). Among the elements that have been used for distinguishing shell middens from shell beds are stratigraphic, compositional (*e.g.*, taxonomic diversity and specimen size), and taphonomic characteristics (*e.g.*, Attenbrow, 1992; Henderson *et al.*, 2002; Beovide *et al.*, 2015). In addition, the thermal alteration of shells is a feature exhibited by archaeological deposits but not recorded in natural shell accumulations (Beovide *et al.*, 2015), although ethnography and archaeological experimental studies showed that shells may not always develop and preserve perceptible changes after cooking (*e.g.*, Meehan, 1975; Villagrán, 2014). Moreover, the presence of artifacts (*i.e.*, human-made objects, such as stone tools or pottery) and/or natural elements (*e.g.*, bones, shell, and wood) that exhibit cultural modifications (*e.g.*, cut marks, spiral fractures, flake scars, and thermal alteration) is considered a diacritical mark for anthropogenic shell accumulations. These cultural shell-rich deposits range in South America from large mounds (such as those of the *sambaquis*; Wagner *et al.*, 2011) through shell middens to thin shell lenses (Zangrando, 2020).

In this paper, we study the origin of thin shell lenses in the north of Isla Grande de Tierra del Fuego (IGTDF) that are spatially associated with the Atlantic shoreline position during the Middle Holocene marine transgression. The regional archaeological background indicates that hunter-gatherer populations inhabited northern Isla Grande since the end of the Pleistocene (Massone, 1987, 2004), but the exploitation of marine resources is only recorded from the Middle Holocene onwards (*e.g.*, Salemme & Bujalesky, 2000; Salemme *et al.*, 2014; Santiago, 2024). Here, we present the multidisciplinary study of a thin shell lens recently exposed by aeolian erosion at the summit of Cerro Bandurrias, a hill located in the south of San Sebastian Bay (Fig. 1.1–2). We describe the deposit (geometry and stratigraphic pedolithological units), characterize its biogenic content and chronology to evaluate different hypotheses for the origin of the Cerro Bandurrias lens that consider geogenic, biogenic, and anthropogenic processes.

GEOLOGICAL AND ARCHAEOLOGICAL BACKGROUND

The north of IGTDF represents the southern extreme of the Magellanic steppe, characterized by a cold-temperate oceanic grassland. The mean annual rainfall is ~350 mm and the mean annual temperature is ~5 °C. The strong and frequent wind from the west/southwest quadrat is the most prominent geomorphic agent of the Fuegian steppe (Garreaud *et al.*, 2009; Coronato *et al.*, 2022).

The Cerro Bandurrias is a low (18 masl) and flat-top hill. As the other hills in the south of San Sebastian Bay, it is a small (470 by 280 m) lithic sandstone outcrop of the Carmen Sylva Formation, dated to the Early to Middle Miocene (Codignotto & Malumián, 1981). Edaphized sediments cover the bedrock on the hilltop. The Cerro Bandurrias is currently located 3.2 km from the mean high tide line, but it stood as the northern extreme of a peninsula surrounded by the sea during the Middle Holocene marine transgression (Codignotto, 1983; Isla *et al.*, 1991; Ferrero, 1996; Vilas *et al.*, 1999; Favier Dubois & Borrero, 2005). The maximum transgression occurred between 8500 and 6000 cal. years BP (Candel *et al.*, 2020; Coronato *et al.*, 2022), and the regressive sequence might have begun by *ca.* 5600 cal. years BP (Vilas *et al.*, 1999). The action of marine waves formed cliffs at Cerro Bandurrias foothills. Upon sea retreat,

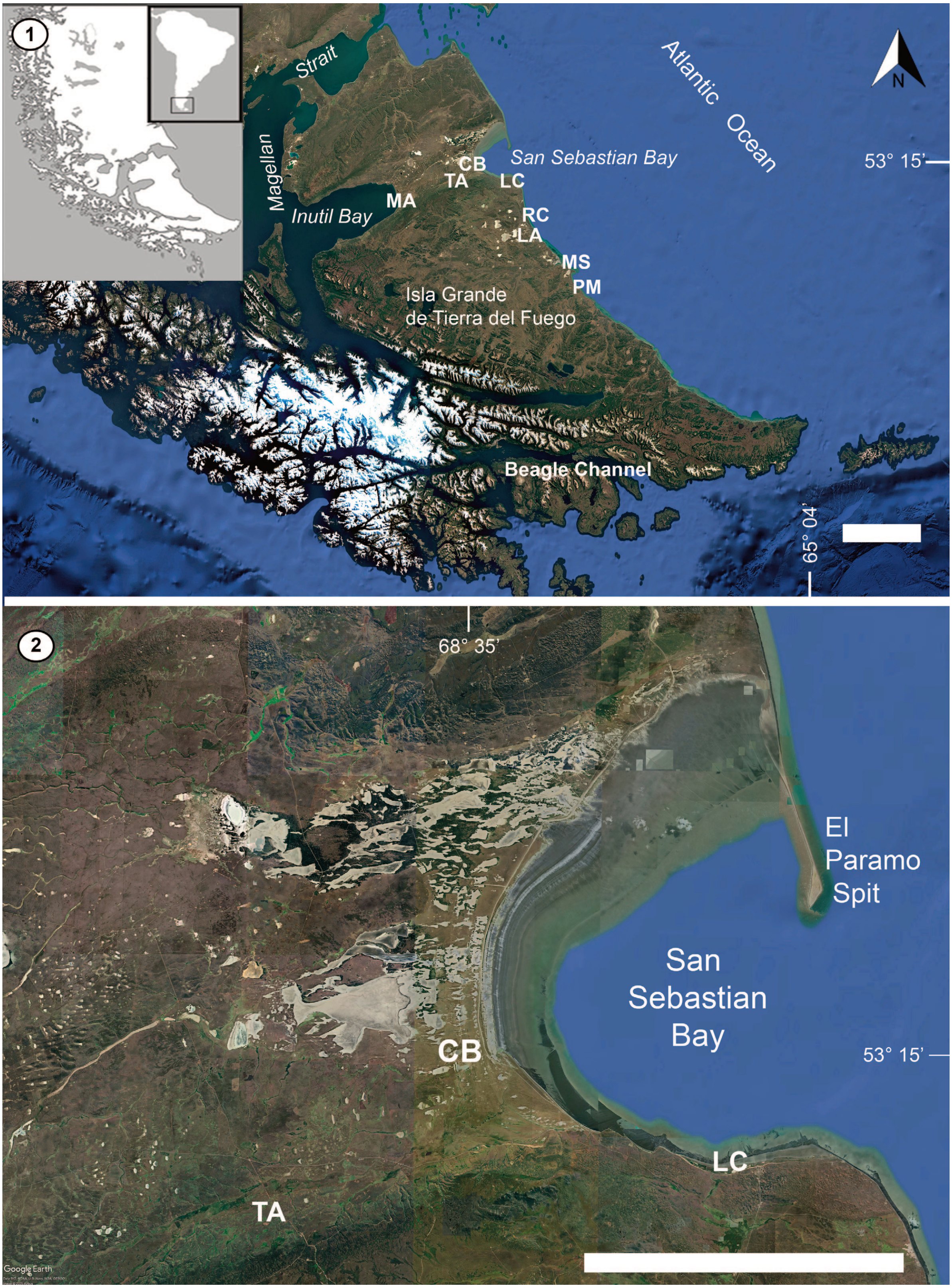

Figure 1. Study region and archaeological contexts mentioned in the text. **1,** Isla Grande de Tierra del Fuego. Scale bar= 50 km. **2,** San Sebastián Bay. Scale bar= 20 km. References: **CB,** Cerro Bandurrias; **LA,** La Arcillosa; **LC,** Los Chorrillos; **MA,** Marazzi; **MS,** Margen Sur; **PM,** Punta María; **RC,** Rio Chico; **TA,** Tres Arroyos. (Image from Landsat/Copernicus 2020; Google Earth, accessed March 2025).

cliff erosion initiated the talus formation at the base of the scarp. San Sebastian Bay evolved with the sea level drop roughly recorded between 5600 and 500 years ago (Fig. 2.1–3). Marshes developed on the emerged plain and grew far from the dominance of the tides (Isla *et al.*, 1991; Vilas *et al.*, 1999; Isla & Bujalesky, 2008; Fig. 2.4). As a result, while the vegetation on Cerro Bandurrias and the other hills includes *Festuca gracillima*, *Poa* sp., and a few specimens of *Berberis* sp., the surrounding plain is occupied by salt grasslands and marshes of *Sarcocornia magellanica* and *Puccinellia* sp. (Bianciotto, 2006). In fact, San Sebastian Bay is the most hypersaline coast of IGDTF mainly due to the existence of extraordinary extensive tidal flats, which in turn, promote the development of marshes with shoals (*restingas*). The bay is bounded to the north by El Páramo, an 18 km-long gravel/sand spit (Isla *et al.*, 1991; Isla & Bujalesky, 2008; Bujalesky & Gonzalez Bonorino, 2015; Borrero & Borrazzo, 2021).

The earliest evidence of human occupations in the IGDTF is dated to the end of the Pleistocene and it was recorded at Tres Arroyos archaeological locality, situated 20 km to the west of Cerro Bandurrias (Massone, 1987, 2004; Fig. 1.1–2). By that time, the island was still connected to the mainland (*i.e.*, continental Patagonia), thus the peopling of IGTDF was made by pedestrian people who inhabited the lands located to the north of the Magellan Strait. Guanaco (*Lama guanicoe*) was the main staple since the early Fuegian occupations.

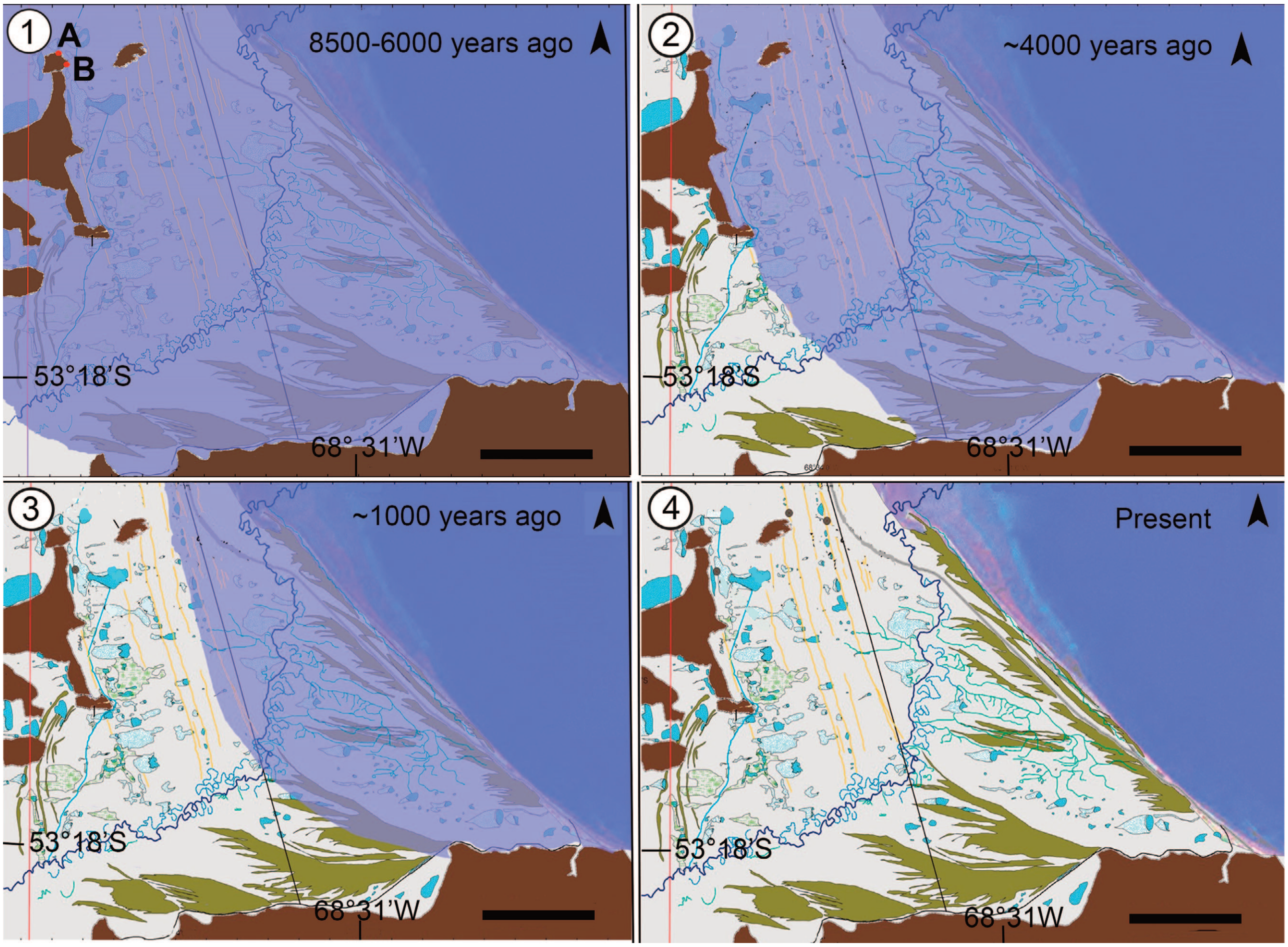

Figure 2. Geomorphological coastal evolution of San Sebastián Bay (based on Vilas *et al.*, 1999; modified from Ozán, 2015). See geomorphological references in Ozán (2015). **1,** Estimated position of the coastline 8500–6000 years ago; **2,** Estimated position of the coastline *ca.* 4000 years ago; **3,** Estimated position of the coastline *ca.* 1000 years ago; **4,** Current position of the coastline in the study area. References: **A,** Location of Cerro Bandurrias shell lens dated by Favier Dubois and Borrero (2005); **B,** Location of Cerro Bandurrias shell lens studied in this paper. Scale bar= 1 km.

Subsequent archaeological evidence is dated to the Middle Holocene. They include a few sites located near Atlantic coastlines (or paleo coastlines) that exhibit remains of marine fauna (shell, fish, and sea mammals) (Salemme & Santiago, 2017). These Middle Holocene marine records are represented by multicomponent shell middens (*e.g.*, Rio Chico 1, Santiago, 2013; La Arcillosa 2, Salemme *et al.*, 2014), although thin shell lenses composed of *Mytilus* sp. are more common (*e.g.*, La Arcillosa 1 and 3, Salemme & Bujalesky, 2000; Rio Chico 6, Salemme & Santiago, 2017). Among the latter, a small *Mytilus* sp. lens was identified within the sedimentary deposits eroded by the wind in the north of the Cerro Bandurrias summit (located 270 m to the northwest of the locus presented in this paper; Fig. 2.1). These shells were dated to 5700 ± 180 ^{14}C years BP (5199–6096 cal. years BP; Favier Dubois & Borrero, 2005). A stone tool (sidescraper) was recovered at the *locus* (Borrazzo *et al.*, 2007).

The Late Holocene provides a profuse and diverse record of the human occupation of coastal and inland Fuegian landscapes on the northern Atlantic slope, especially during the last two millennia (Oría *et al*, 2017). While guanaco remained the primary staple for hunter-gatherers during the Holocene (*e.g.*, Muñoz, 2002; Sierpe, 2020; Santiago, 2024), the exploitation of marine resources introduced during the Middle Holocene became well-established by the Late Holocene.

In sum, two synchronous geomorphological and archaeological processes occurred. Due to littoral accretion, the environment of Cerro Bandurrias turned from marine in the Middle Holocene to inland in the Late Holocene. While this transformation occurred in the landscape, the region was inhabited by hunter-gatherers who increasingly incorporated marine resources into their subsistence since the Middle Holocene.

MATERIALS AND METHODS

A 7 to 10 cm thick shell lens was discovered on the southern hillside of the Cerro Bandurrias in 2022. This feature is observed at 1 m depth, in the sedimentary deposit of the hilltop (Fig. 3.1–3). Horizontally, the shell lens extends discontinuously along 7.47 m in a stratigraphic section exposed by runoff, rotational slides, and wind-driven scarp retreat. Within this shell-rich level, two segments (2.1 and 0.84 m long) that exhibit a rather continuous distribution of shells along the scarp were identified (Fig. 3.1). These two shell lenses are separated by a 4.53 m long gap, along which only isolated gastropods were identified. Beyond this circumscribed sector of the outcrop, shells were not further observed along the scarp in other deflation hollows placed at the top of the hill.

Considering the thin thickness of the lens, its depth below the surface, its location, orientation, and the risk of lens destruction due to scarp retreat favored by the scarce vegetation, we defined a conservative rescue sampling strategy for our study of the *locus*. We surveyed the 2.1 m segment by collecting the loose bioclasts available on the surface and further excavating the scarp profile. The 0.84 m segment of the lens was not sampled in order to avoid introducing large-scale modifications on the scarp exposed to westerlies that would promote accelerated and extensive destruction of the context.

During the excavation, it was observed that shells became scarce until they disappeared into the deposit beyond 15 cm from the scarp surface. We recovered the total biological and sedimentary content of the shell-rich layer along the 2.1 m horizontal segment. Although the shells were complete while contained in the sedimentary matrix, they broke during the extraction due to their fragility. To improve the recovery of complete specimens, the lens was excavated by removing blocks of the naturally cemented matrix using a spatula.

Biological components were separated from the matrix at the laboratory. The specimens of the collection (Cerro Bandurrias-Lente de valvas 2022) are housed in the Archaeology Laboratory of the Instituto Multidisciplinario de Historia y Ciencias Humanas. Bioclasts larger than 5 mm were extracted by picking. Smaller bioclasts (corresponding to fragmented shells and fish bones) were separated from sediments by sieving using a 2 mm mesh. A selection of structured blocks of sediments and shells were stored for future studies.

The description of the skeletal concentration follows Kidwell *et al.* (1986) and Kidwell & Holland (1991). The fauna contained in the lens was determined to the lowest possible taxonomic category and its taphonomic attributes evaluated. Observations of the taphonomic variables of natural and anthropic origin (original color and periostracum preservation, degree of thermal alteration, presence/absence of traces of exfoliation, manganese, cracks, dissolution, abrasion, bioerosion, lichens, root marks, cut marks, anthropic fractures, and decoration) were made macroscopically with the aid of a hand magnifying glass (2.5x) and a stereomicroscope (50x). We followed the methodological guidelines defined by Hammond (2015) and Gutiérrez Zugasti (2008–2009) for malacological specimens and by Lyman (2008) for vertebrate remains.

Geoarchaeological analyses comprised a detailed stratigraphic characterization of pedolithological units exposed in the section, interpreted within their geomorphological context. Classification followed standardized soil horizon nomenclature (*e.g.*, A, C, R horizons; Birkeland, 1999). The

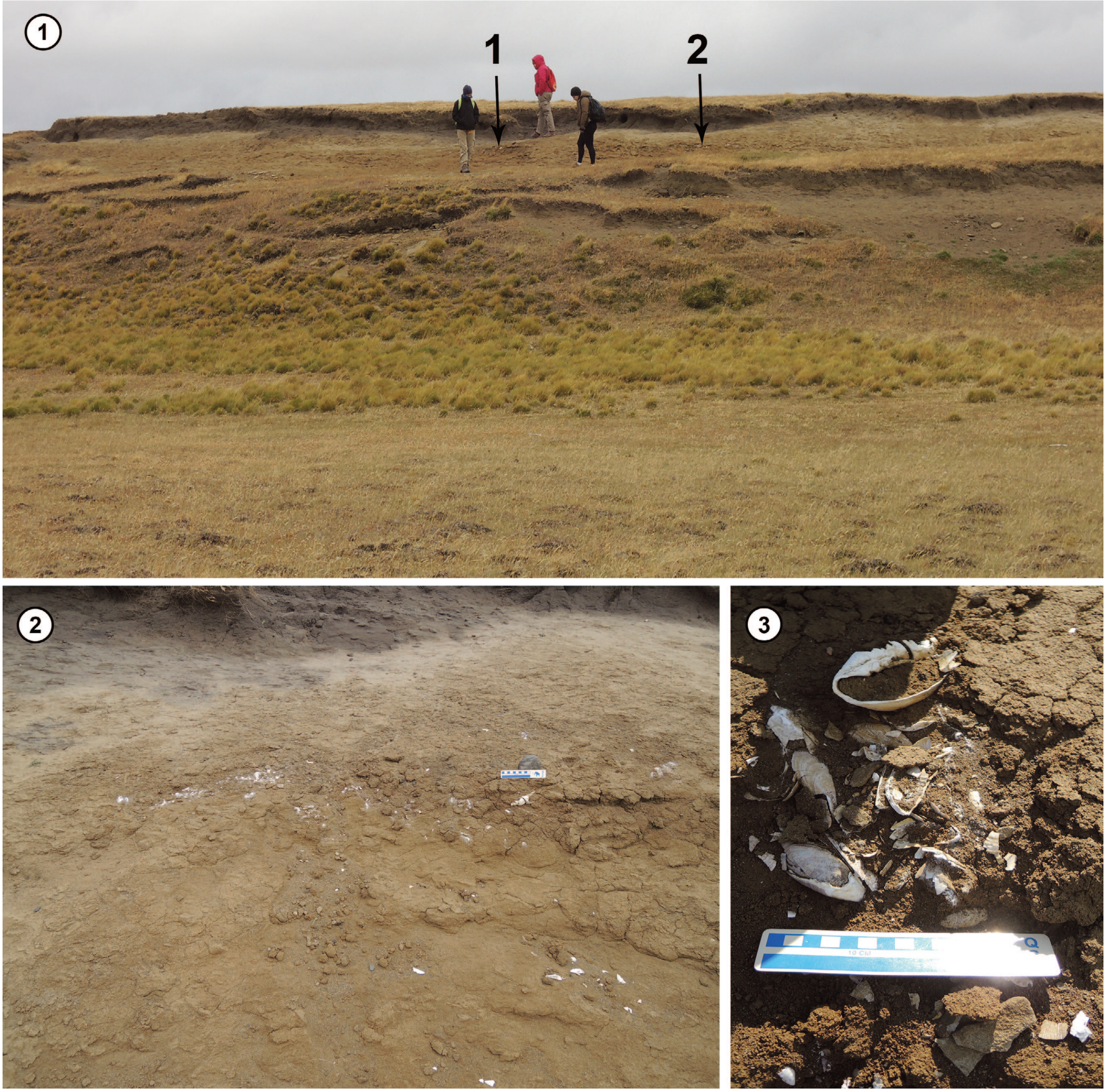

Figure 3. Shell lens on the southern hillside of Cerro Bandurrias. **1,** Location of the 2.1 and 0.84 m segments of the lens, indicated by 1 and 2, respectively; **2,** General view of Cerro Bandurria shell lens; **3,** detailed view of the shell lens. Scale bars= 10 cm.

interpretation of the stratigraphy was also possible due to further regional field observations and prior research on analogous pedosedimentary sequences (Ozán, 2015; Borrazzo *et al.*, 2025). Stratigraphic and sedimentological properties were assessed through texture analysis by feel (USDA triangle, plus visual gravel estimation), color determination (Munsell Color, 1992), and structures observations (type and degree; Birkeland, 1999; Soil Survey Staff, 1999). Analytical data comprised pH measurements (1:2.5 solution in Milli-Q distilled water, Arcano PHS-3E Instrument) and electrical conductivity (EC, mS/cm; Hanna Instrument), with the latter serving as an indirect indicator of seawater influence on sediments (Grayver, 2021). Additionally, bulk magnetic susceptibility (m^3/kg; mass-normalized) was measured at 200 Hz and 1000 A/m using a Kappabridge instrument, to detect sediment combustion signals (Ozán *et al.*, 2020 and references therein). These analyses were conducted on the surveyed stratigraphic section and on one off-site sample. While stratigraphic analysis focused on identifying depositional and post-depositional processes, analytical methods aimed to distinguish between anthropogenic and natural influences.

A vertebra of Osteichthyes was radiocarbon dated at DirectAMS Radiocarbon Dating Services, USA (sample code: D-AMS 048513). Radiocarbon dates were calibrated with Oxcal 4.4 (Bronk Ramsey, 2021) and by using the Marine20 curve (Heaton *et al.*, 2020), at 2σ (95.4%). The local ΔR correction applied for marine resources was 265 ± 45 (Cordero *et al.*, 2003).

RESULTS

Analyses of biogenic content

Bioclasts in the sample include shells and bones. Table 1 summarizes the weight of the different components. Bioclasts represent ~13% of the weight of the sample recovered.

Description of exoskeletal concentration. According to Kidwell *et al.* (1986) and Kidwell & Holland (1991), the Cerro Bandurrias shell lens is a simple exoskeletal concentration. Its taxonomic composition is polytypic (Mollusca and Vertebrata) and paucispecific (*i.e.*, with a few represented, strongly dominated by one species; see below). Cerro Bandurrias lens is also an allochthonous assemblage (*i.e.*, composed of transported specimens out of their life habitats).

TABLE 1 – Sample composition and weight.

		Weight (g)	%
Matrix	Sediments	3331.20	87.05
Bioclasts	Mollusca	467.79	12.22
	Vertebrata	27.71	0.72
	Total	3826.70	100

Regarding its biofabric, shells in the cross-section of the deposit exhibit an oblique orientation; in portions, clustering stacking—without preferential concave-up or concave-down—and nesting patterns are observed in the cross-section (Fig. 4.1–4). The accumulation varies from dense to loosely packed, and it ranges from bioclast to matrix supported. It is poorly sorted and, according to the geometry of the deposit, it can be classified as a thin lens.

Taxonomic composition. The bioclasts in the sample are represented principally by seashells—bivalves and gastropods—and a few fish bones (Fig. 5.1–4). Only 107 (1.52%) out of the 7035 fragments of mollusks were identified to genus and species level (Tab. 2).

Mytilus chilensis is the most represented species in the malacological assemblage. The minimum number of individuals (MNI) is 53 (according to the right valves count). One of the bivalves could only be determined at the Class level due to preservation issues of its outer features (Fig. 4.3). Gastropods are represented by the genus *Odontocymbiola* sp. (MNI = 4), some of which are fragmented shells that preserve their diagnostic features (Fig. 5.2). The scarce vertebrate specimens recovered (n = 138) were identified primarily as fish bones, including at least one *Genypterus blacodes* specimen (Tab. 2).

Chronology. A vertebra of Osteichthyes (Fig. 5.3) recovered from Cerro Bandurrias shell lens was radiocarbon dated in 6566 ± 35 ^{14}C years BP (D-AMS 048513; 6736–6348 cal. years BP; median: 6544 cal. years BP). This calibrated date is similar to the chronology of the Rio Chico 1 archaeological site (Santiago, 2013), located ~50 km to the southeast of Cerro Bandurrias.

Taphonomy. The material—mainly composed of Mollusca—shows low prevalence of destructive factors. The assemblage was dominated by whole specimens while contained in the sedimentary matrix. However, due to their fragility, all the shells broke when they were removed from the sediments at the lab, overestimating the non-natural fragmentation produced by the cleaning procedures (Fig. 6.1). The chemical alteration of shells is also manifested in their chalky and porous aspect as well as the reduction of their weight. Among the *Mytilus chilensis* specimens, fragments ranged from 0.7 to 4.6 cm. Only six *Mytilus chilensis* have more than 90% of the valve complete with the individual diagnostic element present which have an average length of 3.26 cm (min. 2.12; max. 4.6 cm). While this information is not representative of the sizes of this bivalve sample, it shows the presence of specimens of different sizes, with no clear trends in this species. The whole bivalve specimen not determined exhibits the largest size in the assemblage (6.19 cm). The *Odontocymbiola* sp. specimens were all fragmented and they measured between 5.6 and 7.2 cm. Similarly, more than 69.5% of the fragments of indeterminate mollusks exhibited 0.1 to 0.6 cm in length (fragmentation that has a methodological source—cleaning).

Among bivalves and gastropods exfoliation, cracks, abrasion (Fig. 6.2) and loss of periostracum are the taphonomic features with the highest prevalence, with the addition of root marks and chemical dissolution in the *Mytilus* specimens (Fig. 7.1). The same attributes with different frequencies are observed among indeterminate mollusks (Fig. 7.2). Among bioerosion traces, we only considered the presence of marks related to perforations and encrustations. Very low frequencies of these kinds of traces were recorded (*e.g.*, perforation at the apex of a *Mytilus*), which would have occurred on the living specimen. A more in-depth evaluation and detailed quantification of bioerosion marks will be conducted in the future. On balance, the bioclasts show a low prevalence of destructive

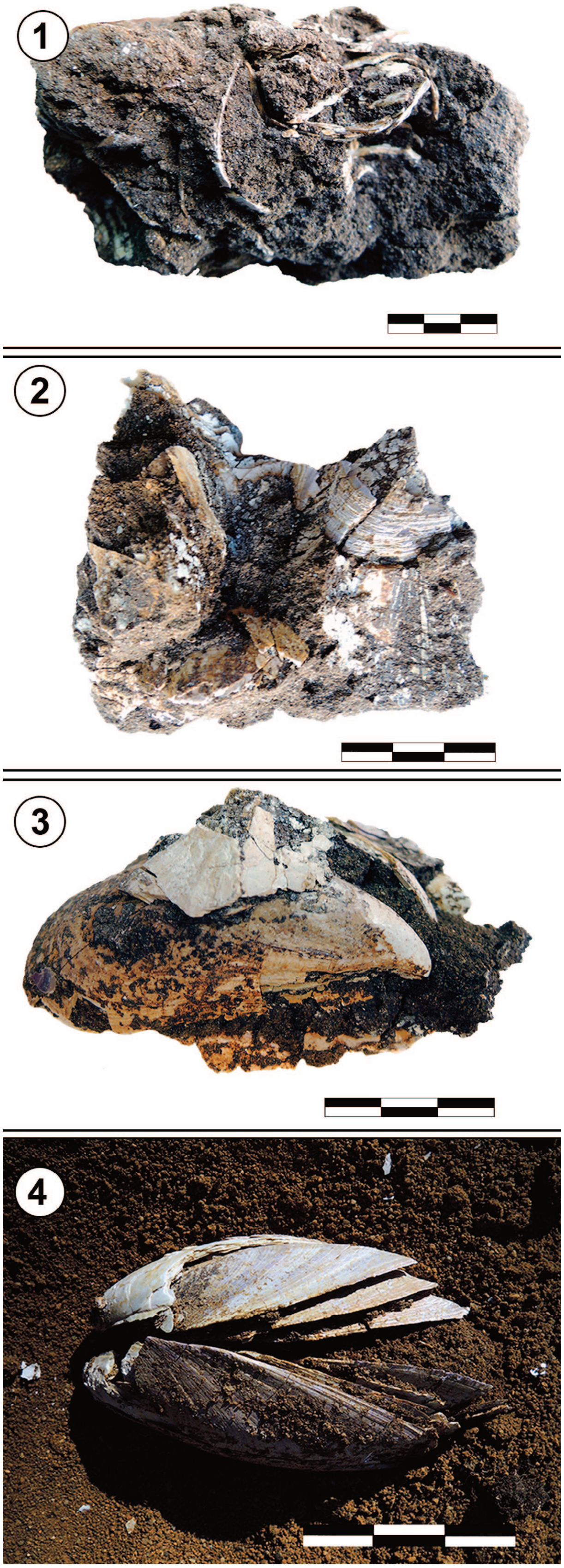

Figure 4. Examples of clustering patterns exhibited by shells in Cerro Bandurrias lens. **1–3,** stacking (three different views); **4,** nesting. Scale bar= 3 cm.

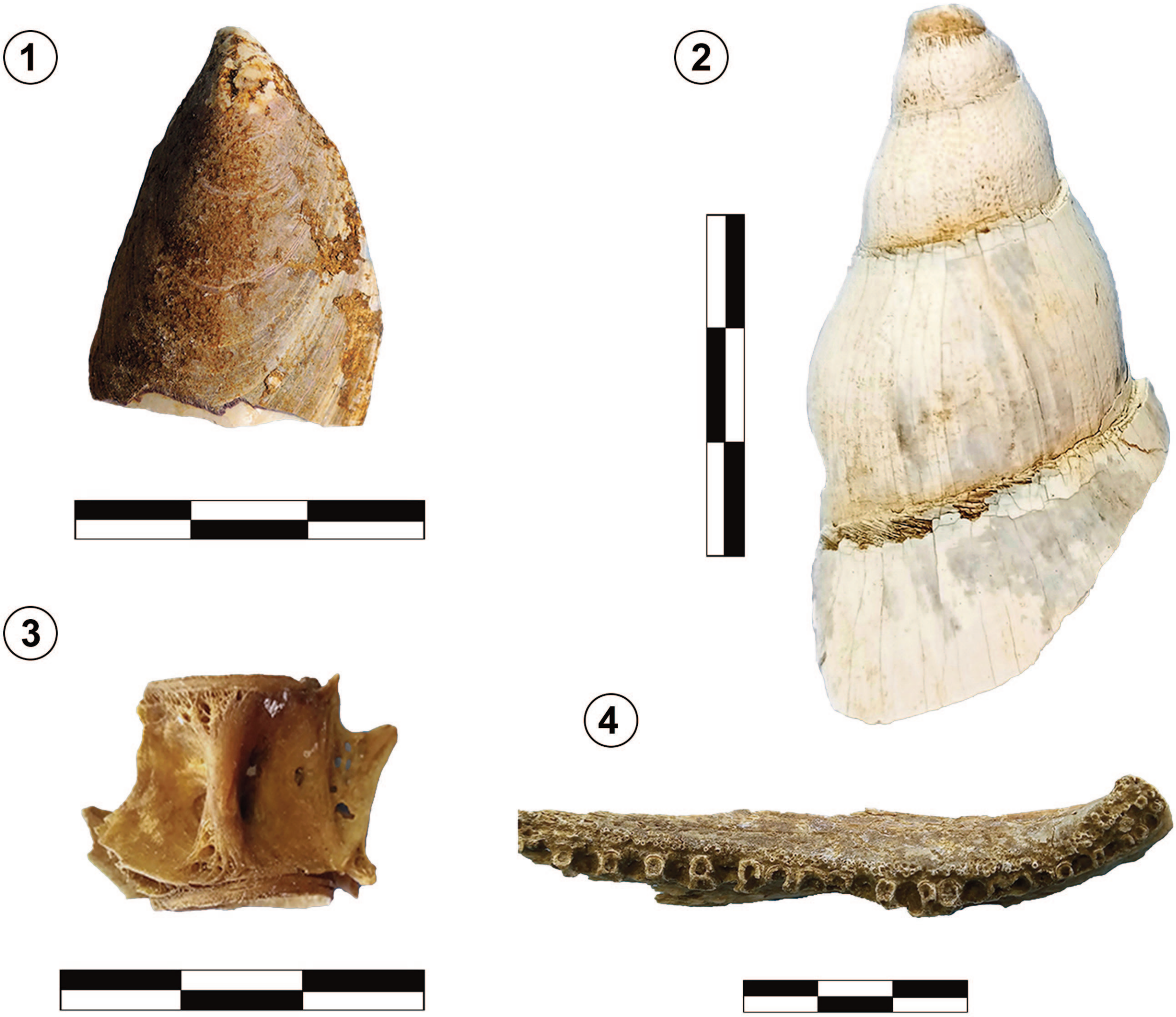

Figure 5. 1, ***Mytilus chilensis***. **2,** ***Odontocymbiola*** sp. **3,** Radiocarbon dated Osteichthyes vertebra. **4,** ***Genypterus blacodes*** mandible. Scale bar= 3 cm.

TABLE 2 – Taxonomic composition of the lens fauna.

	Taxa	n	%
Mollusca (n 7035)	*Mytilus chilensis*	102	1.45
	Bivalvia	1	0.01
	Odontocymbiola sp.	4	0.06
	Indeterminate	6928	98.48
Vertebrata (n 138)	Osteichthyes	88	63.77
	Genypterus blacodes	1	0.72
	Indeterminate	49	35.51
	Total	7173	100

factors, with fragmentation being the variable with the greatest weight.

Only two cases of root marks and one of cortical exfoliation were recorded among vertebrates. The latter corresponds to the lower jaw of *Genypterus blacodes*, which was found subaerially exposed at the recovery. The malacological and vertebrate fauna do not show unequivocal evidence of human manipulation (cut marks, formatting, polishing or decoration of the valves, and thermal alteration). The 5.88% of the bivalve remains show changes in their coloration (*e.g.*, brown and greyish tones; Figs. 5.1, 6.3).

Stratigraphy and sedimentary characterization

In general, the studied archaeological section presents brownish sandy sediments, with different proportions of pelites (*i.e.*, silt and clay) and gravels, comprising poorly to moderate sorting matrices. The pH is neutral to slightly alkaline (7.1–7.7), and the electrical conductivity (EC) shows minimum variations (0.1–0.3 mS/cm). As expected, the pH (8.1) and EC (0.6 mS/cm) from the shell lens sample yielded higher values (Tab. 3). Values of magnetic susceptibility below and above the shell lens and in one off-site sample did not show differences.

From bottom to top, the section begins with the consolidated sandstone of the Carmen Sylva Formation and its regolith, inferred at about 170–160 cm depth since the entire section was not visible in a single exposition, rather in several scarp steps (Figs. 3.1, 8). Above (~160–155 cm depth), in clear contact, a light olive brown (2.5Y 5/4) thin loamy sand level with a weak angular structure is registered (L1 in Fig. 8). Examination of this level with magnification shows the presence of white saccharoidal coatings, filling voids, as cement, which do not instantaneously react with

Figure 6. 1, Fragmented material of Mollusca. **2,** Bioclasts with erosion. **3,** Bivalves showing color change. Scale bar= 4 cm.

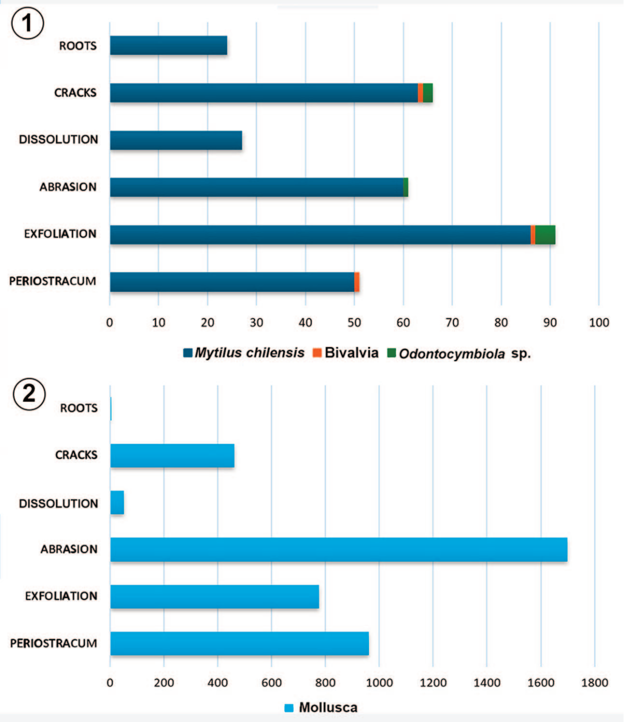

Figure 7. Predominant non-anthropic taphonomic variables. **1,** Bivalvia and Gastropoda; **2,** Mollusks indeterminate fragments.

TABLE 3 – Analytical data related to the stratigraphy of the studied section. Soil related variables following Soil Survey Staff (1999).

Descriptive stratigraphy	Sample depth (cm)	Texture	Color (Munsell color chart)	Structure	pH	Electrical Conductivity (mS/cm)	Magnetic Susceptibility (x10^{-6} m^3/kg)	Comment
L1 (~160–155)	X_1 (~160)	Loamy sand scarce subrounded gravels	Light olive brown (2.5Y 5/4)	Weak angular	7.7	0.25	2.97	Clear contact with lower level. Coatings in voids and grains
L2 (150–70)	X_2 (~100). Next to the shell lens	Loamy sand with frequent subrounded gravels	Dark yellowish brown (10YR 4/4)	Strong angular	7.7	0.14	3.41	Gradual contact with lower level. REDOX features. Cementation
	X_3 (~100). In the shell lens		White speckled in dark yellowish brown (10YR 4/4 matrix)	Massive	8.1	0.39	2.40	
	X_4 (~100). In the shell lens		White speckled in dark yellowish brown (10YR 4/4 matrix)	Massive	8.0	0.32	2.19	
	X_5 (~100). Ca. 10 m away from the shell lens		Dark yellowish brown (10YR 4/4)	Strong angular	7.8	0.16	3.03	
L3 (70/60–30)	n/s	Loamy sandoccasional subrounded gravels	Brown (10YR 5/3)	Single grain	–	–	–	Clear contact with lower level
L4b (~30–20)	X_6 (~25)	Loamy sandoccasional subrounded gravels	Very dark greyish brown (10YR 3/2)	Weak sub-rounded/ crumby	7.2	0.22	3.39	Gradual contact with lower level. High bioactivity
L4a (~20–0)	X_7 (~10)	Sandy loamscarce subrounded gravels		Granular	7.1	0.26	1.80	Welded with lower level. High bioactivity (abundant roots)
Off-site	X (sup.)	Loamy sand scarce subrounded gravels	Brown (10YR 5/3)	Single grain	7.0	0.16	2.41	Sample was taken at the foot of a nearby outcrop (Cerro del Medio)

Abbreviations: **L**, level (depth in cm); **X**, bulk sample (see Fig. 8).

HCl (Fig. 8). It is likely that this illuviated cement comprised Si-bearing precipitations, coming from the sandstone weathering, as it was recorded at other archaeological contexts of northern Tierra del Fuego (Ozán, 2015). Dark and reddish coatings (iron/manganese oxides) are also observed in grains and matrix. In general, all these coatings are conspicuous features produced by illuviation from upper levels, likely related to the shell lens dissolution and mineral weathering. Poorly drainage conditions may favor manganese oxide precipitations.

From approximately 150 to 70 cm depth, a loamy sand level, with frequent subrounded gravels and a strong angular structure is observed in gradual contact with L1. This level (L2 in Fig. 8) depicts dark yellowish-brown hues (10YR 4/4), likely resulting from postdepositional processes related to REDOX conditions (*i.e.*, color) and illuviation (*i.e.*, structure). The occurrence of wet-dry cycles on this level is also observed through dissolution-precipitation features, expressed as cementations. This level contains the thin shell lens, placed around 100 cm below the surface.

Above (70/60–30 cm depth), in clear contact, it is registered a brown (10YR 5/3) single grain loamy sand level (L3 in Fig. 8). On the top of the sequence, and in gradual contact with L3, it is observed a very dark greyish brown (10YR 3/2) level, with a subrounded to crumby weak structure only detected at the bottom (L4b in Fig. 8). Textures are also slightly coarser upwards (L4a in Fig. 8). These levels are clearly related to intense biological activity.

Given the presence of conspicuous edaphological characteristics such as color and structure, this sequence can be undoubtedly interpreted as a soil profile.

DISCUSSION

Depositional and postdepositional evolution

According to the regional geological and chronological information already presented, the Cerro Bandurrias might have been a coastal landform by the time the shells accumulated at the locus (Isla *et al.*, 1991; Vilas *et al.*, 1999). Available data from the stratigraphic section studied here and the information from the sedimentary deposits on other neighbor sandstone outcrops (Favier Dubois, 1998; Ozán, 2015; Borrazzo *et al.*, 2025) allow to understand the sequence of the depositional and postdepositional processes that took place at the Cerro Bandurrias archaeological locality (Fig. 9). Textural and structural data (Tab. 3) suggest that the parent material upon which soil forming factors occurred were deposited by aeolian processes. The rather poor sorting of these sands may be explained by the frequent and high average wind speed in the region, which reaches over 150 km/h, particularly in the

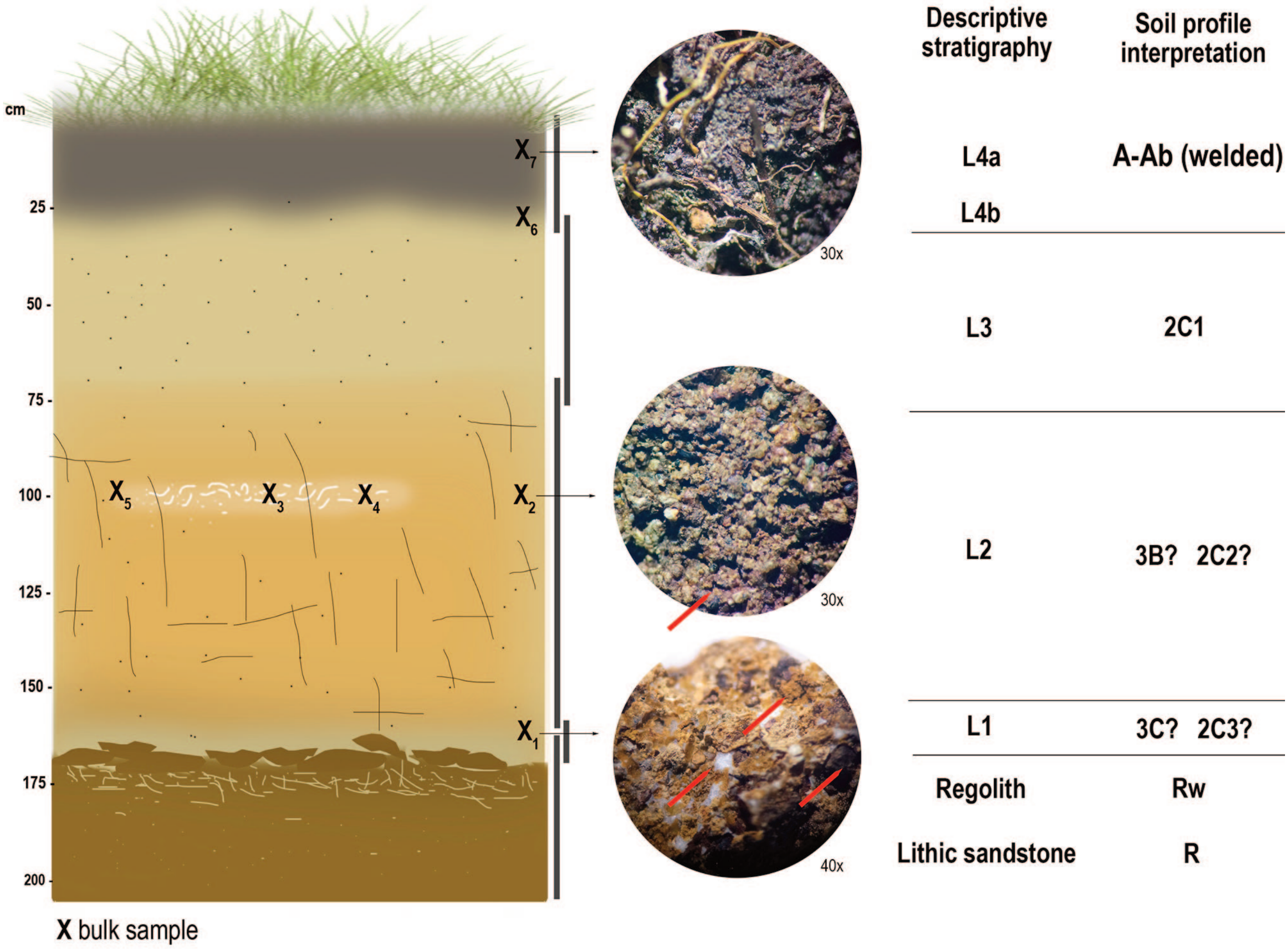

Figure 8. Schematic stratigraphy of Cerro Bandurrias shell lens. Nomenclature refers to a descriptive (left column) versus interpretative (right column) stratigraphic analysis. Red arrows point to the record of (white, red, and black) coatings under the stereomicroscope. Additional analytic data is in Table 3.

summer season (*e.g.*, Vilas *et al.*, 1999; Borrazzo, 2016). This fact poses a pitfall in traditional aeolian literature, where wind deposits are usually characterized by good sorting (Gillies *et al.*, 2012; Wang *et al.*, 2022). In addition, the visual examination of the sand under magnification may indicate that the source of such material is the weathered consolidated sandstone, along with a finer fraction transported by suspension, may be coming from the surrounding lakes (Figs. 1–2).

The shell lens was likely deposited and buried during an aeolian accretion phase, in the context of the Middle Holocene marine transgression (*e.g.*, Bujalesky, 1998). Rapid sedimentological rate might have favored the preservation of the lens and its content (*i.e.*, predominance of whole shells, presence of small-size fish bones) in line with relatively arid conditions (Laprida *et al.*, 2021). Afterwards, two possible scenarios can be inferred from available data (Fig. 9): one related to (A) pedogenesis and another associated to (B) the existence of a cyclical—maybe seasonal—water accumulation. Scenario A is supported by the presence of root marks on some bivalves. In this case, the reddish and structured level could be interpreted as a B soil horizon of a "decapitated" paleosol profile. Such well-developed soil formation, which includes a B horizon, was reported in the Arturo perched dune, before *ca.* 3000 cal. years BP (Coronato *et al.*, 2020; Musotto *et al.*, 2022), in the context of some wet pulses (Coronato *et al.*, 2020, 2022; Laprida *et al.*, 2021).

Scenario B is explained by the periodic permanence of water, likely related to seasonal melting cycles (Fig. 10). This situation might have caused strong REDOX conditions, evidenced in reddish hues and illuviation features, such as the coatings described (Fig. 8). The above-mentioned wet phases could also apply for this B scenario. Beyond which scenario matters in the depositional evolution, it is worth mentioning that the reddish and angular structure of this level correspond to postdepositional processes that took place after the shell lens was deposited, hence they are not contemporaneous. Redox conditions, however, have affected the shell preservation. Although color alteration may result from the exposition of shells to fire (*e.g.*, Villagrán, 2014; Hammond, 2015), its occurrence in Cerro Bandurrias lens is more probably a diagenetic feature related to water accumulation.

Wind sedimentation (*i.e.*, accretion) continued until a well-developed soil took place. This pedogenesis could be attributed to any of those reported regionally for the Late Holocene (*e.g.*, Favier Dubois, 2003; Ozán *et al.*, 2015; Coronato *et al.*, 2020, 2022). An active morphogenesis then buried that soil, and another—yet weak—pedogenesis

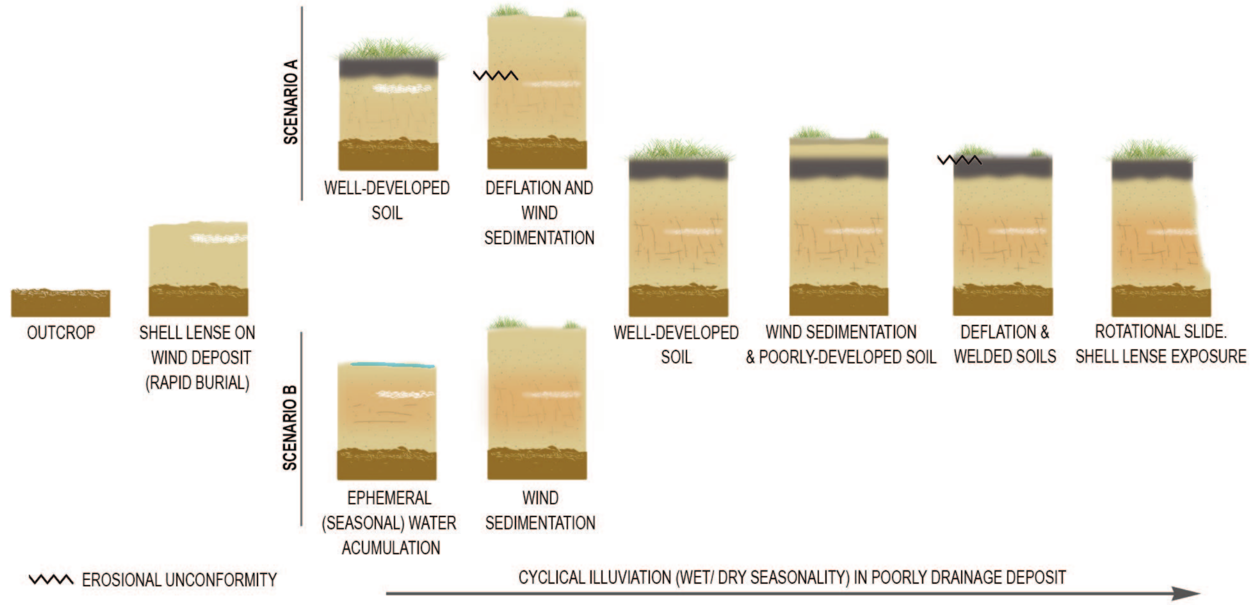

Figure 9. Schematic evolution of the shell lens stratigraphy.

Figure 10. The Cerro Bandurrias locality under a snow cover (June 2024). Also note the presence of sheep (Photo: David Cantero).

occurred (present conditions). In the analyzed section, this last wind deposit was deflated, so the present top soil reset by taking the paleo A (buried) horizon as parent material, resulting in "welded A horizons". In other nearby exposed section, the present soil profile has kept its original parent material.

Shell lens genesis

Several factors preclude ruling out natural or cultural processes as the primary mechanisms for shell accumulation. First, based on the San Sebastian Bay's coastal evolution and the chronology of the fish remains in the lens, the ocean might have been near the locus when the skeletal accumulation occurred. Second, the shell lens lacks univocal anthropic traits (*e.g.*, lithic artifacts, cut marks on bones, polished bones, decorated valves, burnt shells, charcoal). Thus, the Cerro Bandurrias shell lens becomes a genetically challenging deposit. In this regard, three hypotheses concerning the shell accumulation at Cerro Bandurrias are discussed, drawing on different agents and processes. We derive material expectations for each depositional process and then compare and contrast them with the fossil record.

Hypothesis 1: shell lens as a geogenic deposit. This explanation proposes that the natural coastal processes were the primary depositional mechanisms for the shell accumulation. Thus, the shell lens would represent coastal sedimentary facies. As mentioned, Cerro Bandurrias was surrounded by the sea when the shell lens formed (~6500 cal. years BP). All the mollusk species represented in the shell lens are living on the San Sebastian Bay and the Atlantic coast nowadays (Gigli & Loekemeyer, 2011; Santiago *et al.*, 2014), and their shells are usually found on the beach. For *Genypterus blacodes* biological data indicates that this species is living in the region (*e.g.*, Cordo, 2004; Gigli & Loekmeyer, 2011). Geological studies established that the Middle Holocene sea level in San Sebastian Bay and the area of Bueno and Chico rivers were located between

1.5 and 2.7 m above the current storm berm (Montes, 2015; Coronato *et al.*, 2022). Indeed, a value of +1.57 masl was indicated for the Middle Holocene maximum transgressive coast in San Sebastian Bay (Bujalesky, 2007; Montes *et al.*, 2018, 2020). The highest sea level position during the Middle Holocene was not high enough to deposit the shells on the hilltop of Cerro Bandurrias. The shell lens is located at 10 masl, so the locus was out of reach of the flood during the marine transgression. Therefore, the Cerro Bandurrias shell lens cannot be explained as a beach deposit.

The record of Holocene active tectonics is abundant in IGTDF (*e.g.*, Winslow & Prieto, 1991; Bujalesky, 2007). San Sebastian Bay is part of the Inutil-San Sebastian depression, which is bounded by ENE-WSW-striking normal faults (Diraison *et al.*, 1997). This structural configuration is consistent with the regional ENE-WSW convergence of the South American Plate and with neotectonic deformation documented along major regional faults, such as the sinistral strike-slip Magallanes-Fagnano Fault System (*e.g.*, Diraison *et al.*, 1997; Bran *et al.*, 2023). Given that this fault-bounded block has been subsiding as part of a structural depression over the past million years, it is unlikely that the archaeological shell lens under study was located at a lower elevation in the past, thus reducing the probability of past marine floodings. Indeed, the regional study conducted by Montes (2015) at the Chico River (~50 km to the south of Cerro Bandurrias) highlighted the tectonic stability of the area and reported a local relative elevation rate of 0.352 mm/year. These data indicate that the locus of the shell lens at Cerro Bandurrias remained above the sea level during the Holocene.

There are, however, coastal sedimentary facies that do not require flooding for their formation. Cliff-top storm deposits (CTSDs; Smith *et al.*, 2014) are shelly and sandy deposits comprising a fringe adjacent to the marine cliff top. Its deposition is patchy but only found within 10 m from the cliff edge. According to Smith *et al.* (2014), CTSDs are emplaced as air thrown from waves and wind-borne plumes produced by the bores of broken waves striking the base of the cliffs. Occasional rounded pebbles (0.5 to 1 cm diameter) are present in the CTSDs. Other characteristics of these deposits include: (A) dominance of fragmented shells (exhibiting variable weathering and age), and (B) shell fragment's frequency and size increase towards the cliff edge. As we mentioned, shells at the lens were mostly complete while contained in the sedimentary matrix at Cerro Bandurrias. Furthermore, the homogeneous depth and the limited lateral extension of Cerro Bandurrias shell lens suggest that the marine remains resulted from a single or few events occurring during a short period. In addition, although postdepositional processes might have affected the parameter, electrical conductivity values—which are indicative of the presence of total salts—are lower at Cerro Bandurrias sediments (0.14–0.39 mS/cm) than actualistic reference values of marine sediments, like tidal marshes, inter-tidal or backshore deposits (4 and 15 mS/cm) or also berms (1.7 mS/cm) (Ozán, personal observations). In sum, the characteristics of the biogenic content (*i.e.*, whole specimens of few species), the lateral extension, and the geomorphological information do not support the matrix of Cerro Bandurrias lens is of marine origin nor the sedimentary features that characterize the influence of the coastal processes.

Hypothesis 2: ornithogenesis. San Sebastian Bay is a prime habitat for many species of birds, including several migratory shorebirds that feed in its large intertidal mudflats (López Gappa & Cruz Sueiro, 2007). The second hypothesis examined here proposes that seabirds were the primary agents of deposition for the Cerro Bandurrias shell lens, representing the accumulation of food remains left by birds such as seagulls (*Larus* sp.), cormorants (*Phalacrocorax* sp.), oystercatchers (*Haematopus* sp.) and other species that include mollusks and fish in their diets (*e.g.*, Tobar *et al.*, 2019). Naturalistic observations available on the predation patterns of these sea birds report the swallowing of whole fish, the scavenging *in situ* of large fishes stranded on the coast, and the shellfish foraging on the littoral bed and the shoal (*restinga*) (*e.g.*, Demongin, 2008). Oystercatchers may crack the shells of bivalves with their beak to eat the soft tissue at the mussel bank (*e.g.*, Bernat, 2024). Other seabirds that cannot break the shells with their beaks may carry the shellfish up in the air and then drop them from a height onto a hard surface (Ingolfsson & Estrella, 1978). Once the shells crack, the bird eats the flesh. The content of seabird egagropiles may include fish and small mammal bones and mollusk and crab shell fragments. These pellets are less cohesive than non-marine bird egagropiles and tend to disaggregate when they are primarily made up of animal remains (Bang & Dahlstrom, 1975). Areas frequented by sea birds may accumulate shells and bone remains on the surface, exhibiting scattered distributional patterns. If a flat surface is available, the food remains extend in a low-density, homogeneous scatter showing no preferential distribution or concentrations. Fragmented shells are more abundant than whole shells in those scatters.

The bivalve and gastropod shells of Cerro Bandurrias lens displayed a high degree of completeness while in the sedimentary matrix. As we mentioned, the fragmentation of the malacological specimens reported is related to the fragility of the diagenetically altered calcareous valves and, principally, to the subsequent process of cleaning and conditioning in the laboratory. Also, the limited spatial extension of the shell accumulation as well as its biofabric do not favor the ornithogenesis hypothesis. Therefore, the formation of the discrete lens mainly composed of whole shells of few species in Cerro Bandurrias hilltop is unlikely explained as seabird food remains.

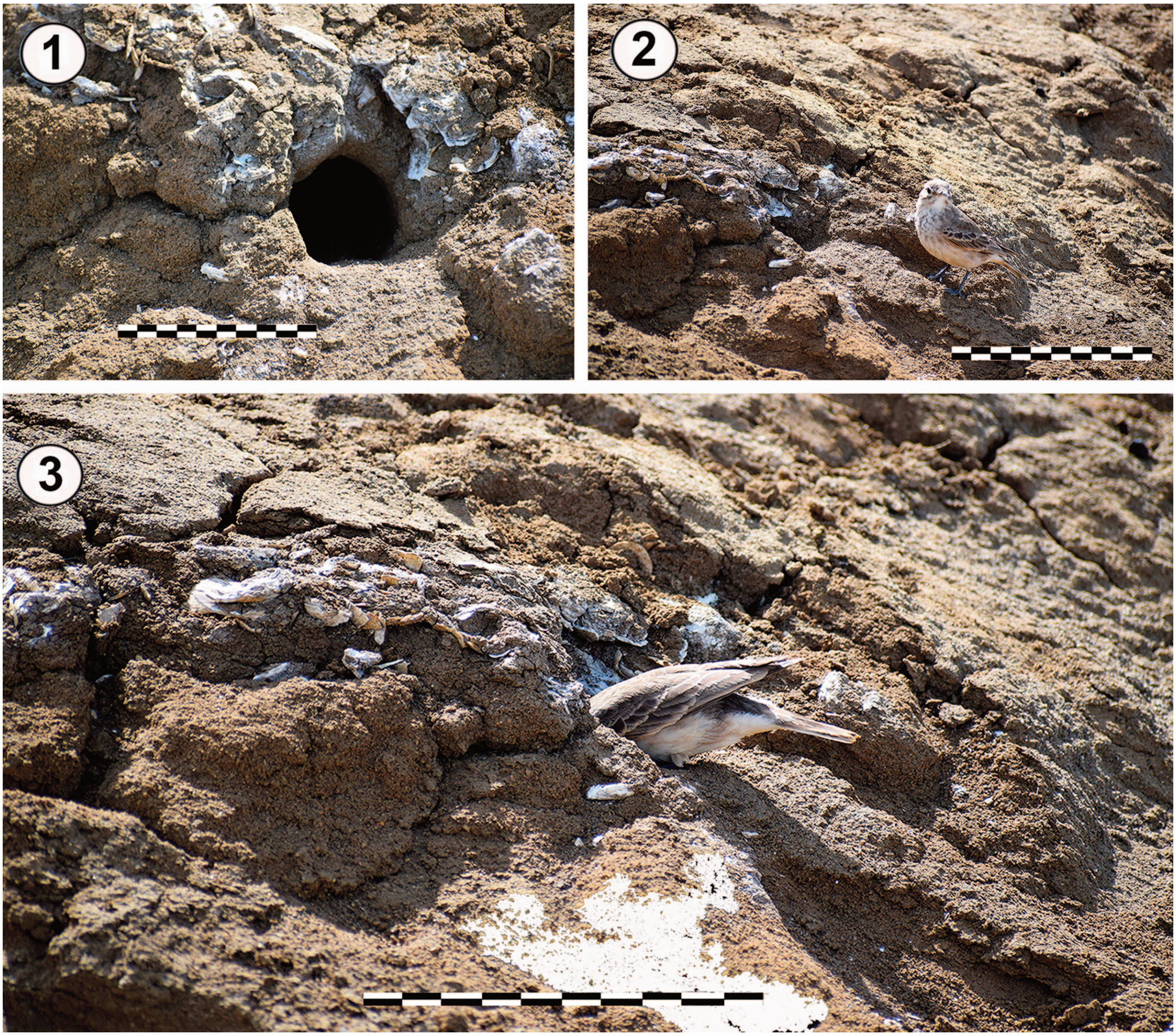

Figure 11. "Common miner" (***Geositta curricularia***) at the Cerro Bandurrias shell lens (Photos: Catalina Balirán). **1,** Entrance of the tunnel excavated by the common miner to build its nest; **2,** "Common miner" standing by the entrance of its nest; **3,** "Common miner" entering the tunnel. Scale bar= 10 cm.

However, it is worth mentioning that we recently confirmed the impact of small birds on Cerro Bandurrias shell lens. During fieldwork in 2024, we observed that a common miner (*Geositta curricularia*) had built its nest within sector B of the exposed shell lens. The common miner excavated a horizontal tunnel in the shell-rich layer (Fig. 11.1–3). The taphonomic effects of this process include the removal of bioclast and sediments from the stratigraphic unit and the addition of exotic elements to prepare the nest, such as vegetal tissue, food remains, feathers as well as the incidental deposition of bones due to a bird's death. Therefore, this nesting behavior causes the partial destruction of the fossil deposit, alter its biological content, and may promote modifications in the stratigraphy as the tunnels collapse.

Hypothesis 3: archaeological shell midden. The third explanation explored here raises the possibility that the Cerro Bandurrias shell lens is an anthropogenic deposit. As mentioned, shell middens can vary in size, ranging from large mounds to thin shell lenses. When it is present, thermal alteration is a diacritic of the anthropogenic origin of shell-rich deposits (*e.g.*, Waselkov, 1987; Claassen, 1998; Beovide *et al.*, 2015; Villagrán *et al.*, 2021). Shell middens are typically found close to coastlines, as they are produced by humans foraging in littoral beds and banks. Fuegian and global ethnographic accounts indicate that shellfish gathering among hunter gatherers is an activity primarily conducted by women (*e.g.*, Meehan, 1975; Gusinde, 1991; Gallardo, 1998). Both the mode of deposition of shells in the archaeological record and the transformations observed after consumption sustain the relevance of Meehan's (1975) observations for IGTDF. The mollusks are collected from the shell bed by hand or using a slate fragment, a pointed or spatula-like wooden stick to help remove the shellfish from the rocks; they usually deposited the mollusks in a basket or a dilly bag (*e.g.*, Meehan, 1975; Gusinde, 1991; Gallardo, 1998). Historical records refer to the *Selk'nam* people inhabiting the northeastern coast of IGTDF collected mollusks when the tide had receded from the beds so that they were exposed (*e.g.*, Chapman, 1986; Gusinde, 1991). In her ethnographic study on northern Australian fisher-hunter-gatherers, Meehan (1975) notes that the shellfish was transported to the camp and immediately cooked. Mollusks were roasted on the coals of a small fire, designed to be fast and hot, and usually only burned for a few minutes (Meehan, 1975, p. 137; Waselkov, 1987). The shells opened when exposed to heat (Waselkov, 1987). The flesh was easily removed and the juice left in the shells after cooking was consumed. Shells were discarded where they had been eaten, forming discrete piles in which pairs of valves attached by the gristle are abundant (*e.g.*, Meehan, 1975). In sum, the activities involved in the manipulation of shellfish for human consumption include gathering from the shell bed, transport, cooking (required for opening bivalves), and discarding shells.

In southern Patagonia, archaeological shell-bearing deposits are recorded up to 80 km from the marine coast (Borrero & Barberena, 2006). These are small cultural shell accumulations that include or are spatially associated with artifacts (*e.g.*, tools) and ecofacts (*e.g.*, food remains) of other raw materials (bone, lithic, pottery, wood, charcoal, etc.) which are more abundant and diverse in large shell middens. The latter are coastal archaeological sites, except for Orejas de Burro which is located 17 km from the coast (L'Heureux, 2008). For the archaeological record on the Fuegian Atlantic coast, a 5 km radius from the coastline was proposed as threshold for regular marine resource consumption (Borrero, 1985).

As mentioned before, the inspection for anthropogenic attributes in the shell assemblage did not provide unequivocal evidence of human exploitation of the mollusk and vertebrate remains. The change in the coloration of bivalves' calcareous surfaces is probably a natural consequence of the contact of the valves with the matrix affected by the cycles of illuviation (see above), and it may not necessarily be a consequence of an intentional thermal alteration aimed at preparation or cooking food. Therefore, assessing the anthropic or non-anthropic character of the Cerro Bandurrias shell lens requires moving the focus to attributes related to the regional context, the depositional history of the lens, and the taxonomic composition of its biologic assemblage.

Among the general attributes exhibited by the remains of mollusks associated with human exploitation could be considered (A) lower taxonomic diversity than the local naturally available (*e.g.*, while modern Fuegian Atlantic beach assemblages include 13 to 9 taxa, archaeological assemblages exhibit only 6 to 3 mollusk species; Santiago *et al.*, 2014); (B) size sorting due to the selection of larger specimens to enhance edible tissue; and (C) low frequency of bioerosion because the live specimens are gathered for consumption (Henderson *et al.*, 2002; Beovide *et al.*, 2015). Shells in anthropogenic deposits may exhibit low fragmentation, since harvested bivalves are transported and deposited out of the taphonomic active zone and opened up on exposure to heat (*e.g.*, Meehan, 1975). Therefore, the completeness of shells may indicate a rapid burial and that they did not remain dead in their natural context. In addition, among hunter-gatherers without navigation technology like the northern Fuegian groups (Borrero, 2001), fish have to be accessible from the coast. Torres (2009) summarized the references available for fishing practices in Fuegian ethnographic accounts. These historical sources informed that northern Fuegians gathered fish and shellfish on rocky shores, also from tide pools, and under stones during the low tide where the intertidal zone extends for more than 2 km or where marine fauna strands (Chapman, 1986; Gusinde, 1991; Coiazzi, 1997; Gallardo, 1998).

Bioclasts in Cerro Bandurrias shell lens are dominated by *Mytilus chilensis.* Gigli and Loekemeyer (2011) stated that *Mytilus chilensis* and *Brachidontes purpuratus* are the more abundant bivalves in the San Sebastian Bay, living fixed by the byssus in the intertidal and sublittoral zones. Although mollusks of Cerro Bandurrias lens are highly fragmented, the shells were complete while they remained in the matrix. The low diversity of species and the dominance of whole specimens are attributes that favor the anthropogenic hypothesis. Due to fragmentation, size sorting cannot be accurately assessed in the Cerro Bandurrias assemblage.

Los Chorrillos, 21 km southeast from Cerro Bandurrias, is the only archaeological locality exhibiting abundant anthropogenic shell-rich deposits in San Sebastian Bay. It is situated on the southern coast of the bay and adjacent to the open Atlantic coast (Fig. 1.2). Human occupation at Los Chorrillos took place on a dune field since *ca.* 1000 years BP (Borrero *et al.*, 2008). Unlike large shell middens from other archaeological contexts, such as Punta María (Borrero, 1985) or the Beagle Channel (Orquera & Piana, 2000, 2001), even in the densely reoccupied archaeological *loci* of Los Chorrillos, shell accumulations are thin (10 cm) horizontal bioclast-supported lenses or matrix-supported shell-rich deposits (Borrazzo & Borrero, 2016). *Mytilus chilensis* is the primary mollusk represented, exhibiting sizes of 5–6 cm, followed by a minor contribution of *Aulacomya atra*, *Nacella* spp., and *Odontocymbiola* sp. (Horwitz, 1995). The presence of *Nacella* spp. in the archaeological record of Los Chorrillos is related to the *restinga* available at the locality that constitutes the only rocky bank on the coast of San Sebastian Bay. Horwitz (1995) suggested that the contribution of *Nacella* spp. increased in the archaeological assemblages located on the Atlantic coast dated after 1000 years BP. Santiago *et al.* (2014) highlighted a spatial trend in shellfish species represented in archaeological shell-rich deposits of the Fuegian Atlantic coast: the dominance of mytilids in assemblages located to the north of Chico River and limpets in the south, probably associated with the different types of substrates that prevail in these two littoral regions and the ecologic requirements of each species. The northern Atlantic coast exhibits alternating rocky bottoms and the presence of sandy and gravelly facies that favor the anchorage of mytilids such as *Mytilus* or *Aulacomya*, which are fixed to these bottoms through the byssus. South of Chico River, the coast presents a more abundant hard substratum adequate for the limpets. According to the chronology of the geomorphological evolution of the bay, the Cerro Bandurrias shell lens was deposited before the formation of the beach barrier lagoon system on which the dune field of Los Chorrillos is located (Vilas *et al.*, 1999). Therefore, human occupation at the latter archaeological locality was only possible at least several centuries later (after 5200 years BP).

A pink cusk eel was identified within the fish remains of Cerro Bandurrias shell lens. *Genypterus blacodes* adults tend to inhabit submarine canyons, at the edge of the continental shelf. In Patagonian waters, they move to shallower depths in spring and summer where they can get caught in little pools of water. The current maximum observed size in female specimens of this species is 140 cm in length and 14,200 g in weight (Cordo, 2004). Although *Genypterus blacodes* is available year-round, its systematic fishing occurs nowadays between January and April, when it is more abundant (Instituto Nacional de Investigación y Desarrollo Pesquero, 2025). Torres (2009) referred to the ethnographic consumption of scaleless fish, such as *Genypterus blacodes* or *Austrolycus* sp., collected at the coast by the *Selk'nam* during the months of the summer and the beginning of autumn. Also, Campan and Piacentino (2004) mentioned that pink cuskeel gets closer to the coast during the spring and the summer (Lloris & Rucabado, 1991). Therefore, the presence of *Genypterus blacodes* in the Cerro Bandurrias shell lens would be an indicator of the seasonal human use of the coastal resources. *Genypterus blacodes* has been identified in the Late Holocene ichthyoarchaeological assemblages of the San Genaro 1 and 2 sites (Los Chorrillos locality) where the medium and large size specimens were the most represented (Campan & Piacentino, 2004; Fig. 1.2). Also, it has been recorded in Late Holocene archaeological sites located in the Inutil Bay (Marazzi 2 and 38; Torres, 2009) and on the Atlantic coast (Margen Sur archaeological site, Salemme *et al.*, 2019). More importantly, *Genypterus blacodes* is also represented in Middle Holocene archaeological assemblages of Rio Chico 1, on the Atlantic coast (Santiago, 2013; Fig. 1.1). Torres *et al.* (2024) point that cusk eel was consumed more between 7500 and 2800 cal. years BP in the Magellan Strait, in particular during the Initial Late Holocene (3400–2700 years BP), when it increases its contribution in the zooarchaeological assemblages. However, the authors report a marked decrease in the abundance of *Genypterus blacodes* in the archaeological record during the Recent Late Holocene (after 2700 years BP). In sum, adding the evidence from Cerro Bandurrias, *Genypterus blacodes* is a species represented in the Fuegian ictioarchaeological record since the Middle Holocene, hence its generally low contribution suggests it remained an occasional resource for Fuegian hunter-gatherers.

Middle Holocene archaeological shell accumulations on the Atlantic slope are scarce. La Arcillosa locality (53 km to the south of Cerro Bandurrias) is integrated by three archaeological sites (LA 1, 2, and 3) that are located on the ravine of Chico River (Fig. 1.1). Like Cerro Bandurrias shell lens, they are deposited in aeolian sediments with poor drainage laying on the Carmen Sylva Formation. The LA 1 and 3 sites are thin shell lenses with *Lama guanicoe* fragmented bones and very few lithic artifacts spatially associated (Salemme & Bujalesky, 2000; Salemme *et al.*, 2014). The LA 2 site is a shell lens with a primary human inhumation dated 6175–5744 cal. years BP (Santiago, 2013). The Rio Chico 1 site comprises an 8 m long, and 10 to 40 cm thick shell lens located in an eolian deposit (Fig. 1.1). *Mytilus chilensis* is the most represented species in La Arcillosa and Rio Chico shell accumulations, exhibiting sizes over 4 cm. *Aulacomya atra*, *Nacella* spp., *Mulinia edulis*, *Odontocymbiola magellanica*, *Pareuthria plumbea* and cirripeds are also present (Santiago, 2013). Both La Arcillosa and Rio Chico were coastal locations by the Middle Holocene but, due to coastal accretion, like Cerro Bandurrias, they became inland spots during the Late Holocene.

The nesting pattern in the lens cross-section exhibited by bivalves in Cerro Bandurrias may inform about the postdepositional history of shells before their burial (*i.e.*, the accumulation of shells after the hunter-gatherer's manipulation). After their deposition on the hilltop and while exposed on the surface, shells were probably subjected to wind action, the most powerful geomorphic agent of the Fuegian steppe. Aeolian erosion in the area is known for winnowing artifacts weighing up to 13 g from surface lithic scatters when the wind blows at 80 km/h (Borrazzo, 2016). Therefore, it is possible to suggest that *Mytilus* shells were reordered and accumulated by airflow while remaining subaerially exposed (likely for a brief period) until their final burial. In addition, the presence of small bones suggests that fish remains were deposited and buried while they were still covered by soft tissues. The latter fact also suggests the lens may have had a short subaerial exposure before burial.

Therefore, the locus on the southern hilltop of Cerro Bandurrias presented here together with the previously reported thin shell lens on the northern slope (Favier Dubois & Borrero, 2005) record reiterated occasional consumption of seafood by Fuegian hunter-gatherers at the locality. Thus, the hilltop of Cerro Bandurrias preserves the ephemeral record (*sensu* Borrero, 2023) of marine fauna exploitation by the Middle Holocene. Further dating of shells from the locus studied here will adjust the temporal frame for the lens formation and it also will allow exploring the persistence of this subsistence practice.

CONCLUSIONS

The assessment of the spatial, pedolithological, taphonomic, and compositional characteristics of the Cerro Bandurrias hilltop stratigraphic sequence suggests that the shell lens constitutes an anthropogenic deposit. The geoarchaeological assessment of the *locus* indicates that although the thin lens was buried rather rapidly after its formation, subsequent water-related postdepositional processes, favored by poor drainage and probably more humid conditions, introduced significant changes in the sedimentary matrix affecting shell preservation.

Cerro Bandurrias shell lens represents a new Middle Holocene archaeological context in the Fuegian steppe and provides additional evidence of human-sea relationship. It is the ephemeral record of a minor marine component in the human diet by Middle Holocene times, a trend shared with the Atlantic coastal archaeological contexts of similar chronology. The study of Cerro Bandurrias shell lens allows us to access the material remains of a strategy described in historical and ethnographic accounts but scarcely recorded in the archaeological literature. The presence of *Genypterus blacodes* in the assemblage agrees with the regional archaeological background. By the Middle Holocene, fish may have been a complementary marine resource acquired by the casual encounter and gathering of isolated specimens (stranded or trapped) during shellfish harvesting tasks.

The case of the shell lenses of Cerro Bandurrias also emphasizes the critical role of the archaeological interception (*i.e.*, the moment of the archaeological discovery) for this fragile archaeological record in the Fuegian steppe. Once exhumed, the evidence of these ephemeral occupations is subjected to highly dynamic processes, and therefore, its survey is only possible for a short period before its destruction (*e.g.*, northern shell lens in Cerro Bandurrias hilltop, Favier Dubois & Borrero, 2005; RCH6, La Arcillosa 1 and 3, Salemme & Santiago, 2017; Santiago, personal communication). Finally, the case of Cerro Bandurrias shell lens highlights that the conspicuous character of shells improves the visibility—and thus the detectability—of the archaeological record produced by short-term, non-redundant occupations of hunter-gatherers.

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