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Challenges for microwear analysis of figurative shell ornaments from pre-Colonial Venezuela

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ABSTRACT

Figurative ornaments displaying biomorphic and geometric designs have often been recovered from pre-Colonial sites in the Caribbean and northern South America. Such artefacts are held in museum and private collections, but often have not been the focus of systematic research. On the other hand, recent research into ornaments worldwide has focused on simple beads and automorphic shell ornaments. In this article, microwear analysis is used to assess technologies of production and use-wear of figurative shell ornaments from north-central Venezuela. It is our goal to reflect on the challenges posed by such collections, in terms of reproducibility of traces through experiments, post-depositional and curatorial modifications, and the complexity of past attachment configurations. The underlying question is how to deal with the limitations posed by the very nature of the studied collection in terms of preservation and of the high skill required in the reproduction of figurative artefacts.

1. Introduction

In recent years, a number of microwear studies have been conducted on the topic of production technologies and use of archaeological bodily ornaments, especially beads and pendants. Specimens made of stone, minerals and hard animal materials, such as shell and teeth have received considerable attention (e.g., Bonnardin, 2008, 2012; D'Errico et al., 2009; Gorelick and Gwinnett, 1989; Groman-Yaroslavski and Bar-Yosef Mayer, 2015; Gutiérrez-Zugasti and Cuenca-Solana, 2015; Rigaud et al., 2014; Sax and Ji, 2013; Stiner et al., 2013; Van Gijn, 2006, 2014a; Vanhaeren et al., 2006; Vanhaeren and D'Errico, 2003). Automorphic shell artefacts and simple geometric beads predominate as the main objects of study. In spite of the abundance of shell and lithic ornaments recovered in the circum-Caribbean, a microwear approach has only seldom been applied to such artefacts (De Mille et al., 2008; Falci, 2015; Lammers-Keijsers, 2007; Serrand, 1999). It is our goal to show how the ornaments from the region can bring new insights for the field of ornament studies worldwide.

In the circum-Caribbean, figurative ornaments made of lithic materials and shells were recovered from Early Ceramic Age sites (400 BCE–600 CE/800) in the Lesser Antilles and Puerto Rico and from the Late Ceramic Age (600 CE/800–1500) in the Greater Antilles and north-eastern South America (Antczak and Antczak, 2006; Boomert, 1987, 2001; Chanlatte Baik, 1984; Falci, 2015; Hofman et al., 2007; Narganes Storde, 1995). The pendants depict beings with zoomorphic (e.g., frogs, turtles, and birds) and/or anthropomorphic (males, females, or undefined) traits. A wide range of lithic materials was used for the production of figurative ornaments, including calcite, plutonic rocks, jadeite, nephrite, and serpentinite (Boomert and Rogers, 2007; Hofman et al., 2007, 2014a; Murphy et al., 2000; Rodríguez Ramos, 2010, 2013; Watters and Scaglion, 1994). In northern South America, ornaments, especially frog-shaped pendants known as *muiraquitãs*, have been widely exchanged, as suggested by their wide occurrence across the Amazon and the Guianas during the late pre-Colonial period (Barata, 1954; Boomert, 1987; Moraes et al., 2014; Falci and Rodet, 2016; Rostain, 2006, 2014). The *muiraquitãs* are made of varied raw materials, including jadeite, nephrite, albite, variscite-strengite, and quartz (Meirelles and Costa, 2012). Bivalve and gastropod shells, common raw materials on the islands and the coast of South America, have also been shaped into biomorphic ornaments (Antczak and Antczak, 2006; Lammers-Keijsers, 2007; Murphy et al., 2000; Vargas Arenas et al., 1997). Such artefacts received attention from researchers interested in iconographic designs, raw materials, cultural interaction, and cosmologies in the circum-Caribbean (e.g., Boomert, 2001; Chanlatte Baik, 1984; Hofman et al., 2007, 2014a; Laffoon et al., 2014; McGinnis, 1997; Mol, 2011; Roe, 2011). However, technology and use-wear remain underexplored.

The present research focuses on figurative ornaments from the eastern shore of Lake Valencia in north-central Venezuela. Produced in the area from approximately 800 CE to 1500, the ornaments have been associated with other *muiraquitã* production centres, due to the similarity in iconographic motifs (Boomert, 1987; Rostain, 2006, 2014). Many artefact assemblages from the Valencia Lake Basin are the result of

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unsystematic excavations during the late 19th and 20th centuries (Antczak and Antczak, 2006; Díaz Peña, 2006). A collection of ornaments made of shells and lithics is currently housed in the Ethnologisches Museum Berlin (formerly the Museum für Völkerkunde). The artefacts display multiple perforations, notches and figurative elements. Such elaborate morphologies lead us to questions regarding the presence of highly skilled and specialized craftsmen in the region, as suggested by other researchers (Vargas Arenas et al., 1997).

At the same time, designing a research methodology necessitates an evaluation of whether task-oriented experiments can offer us insight into production technologies and patterns of wear. Similarly, post-depositional surface modifications (PDSM) and long post-excavation trajectories have to be taken into account during analysis. It is necessary to assess how detrimental those are to a microscopic analysis. The aim of the present article is therefore threefold: 1) to present the results of the microwear analysis of the ornaments and suggest new avenues for future research in the studied regions; 2) to discuss the challenges faced during laboratory analysis and interpretation; and 3) to demonstrate how microwear analysis can shed light into the complex biographies of figurative ornaments which involve multiple stages of production and use.

1.1. The Valencia Lake Basin

The north-central Venezuela region comprises a rich combination of diverse geological and topographic features, and ecosystems. From north to south it includes: 1) the oceanic islands and archipelagos; 2) the Caribbean coast; 3) the Cordillera de la Costa mountain range; and 4) the Valencia Lake Basin with islands and alluvial/lacustrine fertile valleys (Fig. 1). To the south, the Serranía del Interior separates the lake from the llanos (savanna plains) and the Orinoco River valley. The geographical centre of the study region is Lake Valencia, a landlocked formation that dates back to the Middle Tertiary (Böckh, 1956; Schubert, 1978, 1980). Located in an area with seasonally dry tropical climate, the lake is the largest, permanent freshwater reservoir in lowland South America, north of the Amazon (Bradbury Platt et al., 1981; Curtis et al., 1999; Leyden, 1985; Raymond and Chardón, 1941; Xu and Jaffé, 2008). It rests at an altitude of 402 m ASL, and has a spill point at 427 m ASL, attaining a maximum depth of 38 m. It covers an area of 350 km^2 with a watershed of 2646 km^2. In the recent past, the lake reached a maximum areal extent of 1050 km^2 and a maximum depth of 63 m (Berry, 1939). The Valencia Lake Basin and the Cordillera de la Costa mountain range to the north are geological formations rich in a variety of rocks of igneous and metamorphic origin (Berry, 1939; Urbani, 2000; Urbani and Rodríguez, 2003).

The basin was a magnet for humans probably since the late Pleistocene-initial Holocene times. It housed pottery making horticulturalists since the beginning of the Common Era, and from 800 CE, the bearers of Valencioid material culture. Around 1200 CE, these societies fostered the conformation of the Valencioid Sphere of Interaction that covered the entire north-central Venezuela region (Antczak and Antczak, 2006). On wide geographical scale of northeastern South America, the region has been portrayed as an entrepôt of interregional exchange, and the circulation of peoples and ideas to and fro the Andean west, the insular Caribbean north, and the Tropical Lowland south (Kidder, 1944, 1948; Osgood, 1943; Osgood, 1943; Rouse and Cruxent, 1963).

Thousands of artefacts have been collected by amateurs and scholars since late 19th century (Ernst, 1895; Marcano, 1971[1889–1891]; Requena, 1932). However, attention was placed on artefacts with perceived “museum value”, leading to a limited collection of non-formal lithic tools. In the cases when lithics were collected in stratigraphically controlled excavations (Bennett, 1937; Del Valle and Salazar, 2009; Kidder, 1944; Osgood, 1943), they were not thoroughly studied. Preliminary studies were conducted on lithic artefacts from the north-central coast (Martín, 1995) and from the Los Roques Archipelago (Antczak and Antczak, 2006). Diverse lithic raw materials have been reported in tools from the Valencia Lake Basin, including chert, schist, andesite,

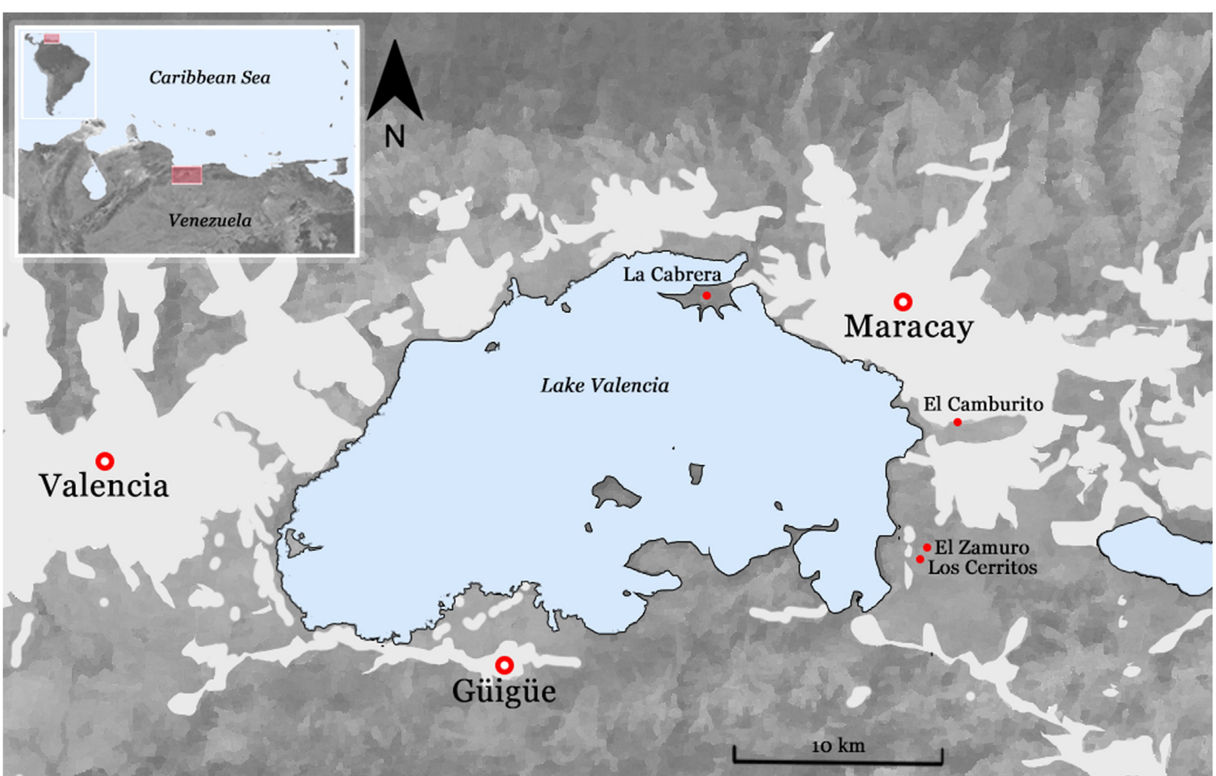

Fig. 1. The north-central Venezuela region with Lake Valencia in its centre and the archaeological sites of Los Cerritos, El Zamuro, El Camburito and La Cabrera situated on its eastern and north-eastern shores. Maracay, Valencia and Güigüe are modern cities surrounded by urbanized and industrialized areas. Map by Oliver Antczak.

granite, sandstone, quartzite, and steatite (Kidder, 1944). It is likely that some of these raw materials were regionally available around the shores of the Lake Valencia and in the Cordillera's coastal bays.

Numerous beads and pendants made of a variety of materials (shells, lithics, bone, metal, etc.) have been recovered from domestic and burial contexts in artificial mound structures in the Valencia Lake Basin (Antczak and Antczak, 2006). Many ornament raw materials are not local and were brought from different areas of Venezuela; for instance, serpentinite was probably traded from the Andean region and jet from the Venezuelan south or west (Cirimele, 1989; Wagner and Schubert, 1972). In the case of the shell material, both the recent and the archaeological distribution of different mollusc species on the coast and islands immediately to the north have been the topic of extensive previous studies (Antczak, 1998; Antczak and Antczak, 2005, 2006, 2008). Marine shells, especially *Lobatus gigas* (commonly known as Queen Conch), seem to have held great importance and were not only used as food source, but also for making bodily ornaments, musical instruments, and tools. Whole and preliminarily shaped shells were brought to the basin from the coast and the offshore oceanic islands, through a total distance of 150 km across the Cordillera de la Costa, with peaks reaching up to almost 3000 masl (Antczak and Antczak, 2006, 2008). While there is no available information on a potential ornament making toolkit, corals brought inland together with the shells and recovered from the archaeological sites could have been used as grinding platforms (Berry, 1939, 558).

2. Materials and methods

The ornaments analyzed in this paper come predominantly from sites located on the eastern shore of the Lake Valencia (Fig. 1). The collection was excavated between 1901 and 1903 by Alfredo Jahn, an engineer commissioned by the Museum für Völkerkunde Berlin (Antczak and Antczak, 2006; unpublished results; Jahn, 1932; Osgood, 1943). The entire collection consisted of approximately 1000 artefacts made of ceramics, lithics, and shell from the sites of Los Cerritos, El Zamuro, El Camburito, and La Cabrera. The collection included "28 necklaces" of different raw materials, although the actual numbers are not clear. Almost a quarter of the whole collection comprised lithic beads and pendants, as well as abrading and pecking lithic tools. However, no contextual or stratigraphic data is available for most objects. Moreover, a significant part of Jahn's original collection has been lost over time, particularly bodily ornaments (Antczak and Antczak, unpublished results; Díaz Peña, 2006). The surviving artefacts identified as potential bodily ornaments ($n = 62$) were analyzed through microwear analysis (Falci, 2015). For the purpose of the present paper, 15 carved shell ornaments are discussed, which encompasses the beads and pendants with figurative and geometric shapes (Fig. 2). Table 1 includes a summary of the information gathered for each analyzed artefact.

2.1. Description of the material

The ornaments from the studied Lake Valencia collection are xenomorphic, since the blanks for their production had to be removed from the shell before being shaped into an ornament (sensu Lammers-Keijsers, 2007; Linville, 2005; Vargas Arenas et al., 1997). In contrast, automorphic artefacts are directly made from whole shells which undergo minimal modification. While beads of simple geometric shapes are also xenomorphic, this article focuses on ornaments with complex morphologies, especially non-circular, asymmetrical, and biomorphic. Most ornaments discussed in this study are classified as pendants (66,7%), given the decentred position of the perforations (cf. Barge, 1982; Watters and Scaglion, 1994). Despite the abundance of shell beads reported from the region, only five beads were analyzed, due to their irregular shape mimicking the folded legs of a frog.

The use of shells as raw materials in the pre-Colonial Caribbean can be related to their properties, such as colour, workability, toughness, and homogeneity (Clerc, 1974; Serrand, 1999, 2007; Sutty, 1990). In the studied collection, bivalve shells predominate, including *Spondylus americanus* ($n = 9$) and specimens of unidentified genera ($n = 3$). The *S. americanus* shell (known as Atlantic thorny oyster) is characterized by a relative thickness, large size, red colour, and thorny appearance with long spines (Abbott and Dance, 2000) (Fig. 3a). The gastropod *L. gigas* is also present in the collection ($n = 3$) (Fig. 3b). Its shell is large, thick, and has a cross-lamellar microstructure, rendering the shell tough and suitable for the production of tools and ornaments (Kamat et al., 2000; Lammers-Keijsers, 2007; O'Day and Keegan, 2001). The lip was commonly used for artefact manufacture, due to its large size and thickness, but other parts such as the body whorl, the columella, the spire, and nodules have also been used by Amerindian communities (Antczak, 1998; O'Day and Keegan, 2001; Serrand, 1999, 2007).

Shell artefacts can undergo a range of post-depositional mechanical and chemical processes that eliminate or superimpose anthropogenic traces depending on the conditions of the soil (Claassen, 1998; Cuenca-Solana, 2013; Cuenca-Solana et al., 2015; Dittert et al., 1980). Surface erosion, pitting and detachment of the coloured layer were observed on some analyzed ornaments (11; 73,3%) (Fig. 4a–b). Additionally, 12 ornaments (80%) have sediment from the archaeological deposits encrusted to the surface (Fig. 4b, c). Breaks were observed on two artefacts, one displaying an old patina while the other one appeared fresh and recent.

Long-term curation and storage may also result in modifications of artefact surfaces. Different systems of identification were used in the past: the attachment of labelling stickers to the surfaces of two ornaments (13,3%), ink markings (7; 46,7%), and nail polish (5; 33,3%). Both systems can be observed on the same artefact due to successive recording episodes. When added to the surface, nail polish creates a reflective layer that hinders the use of high-power magnifications for analysis (Fig. 4d). Pencil lead stains, accidentally created during the drawing of artefacts, were also noted (4; 26,7%) (Fig. 4b). Even though the modifications covered part of the surfaces of the ornaments, none of them rendered analysis impossible; certain traces and residues had to be nevertheless considered with caution. Likewise, for certain specimens, analysis had to be restricted to low magnification.

2.2. Microwear analysis and experiments

A broad range of research has been conducted on technologies of production of shell ornaments in the circum-Caribbean (Carlson, 1995; Falci, 2015; Lammers-Keijsers, 2001, 2007; Serrand, 1999, 2007; Turney, 2001; Van der Steen, 1992; Vargas Arenas et al., 1997) and elsewhere (e.g., Barge, 1982; Bar-Yosef Mayer, 1997; D'Errico et al., 1993, 2005, 2009; D'Errico and Villa, 1997; Francis, 1982; Stiner et al., 2013; Suarez, 1981; Taborin, 1991, 1993; Tátá et al., 2014; Vanhaeren et al., 2006; Velázquez-Castro, 2011, 2012; Thomas, 2015). Microwear analysis has proved to be successful in identifying perforating techniques, differentiating them from natural features caused by predators and by wave and sand action (Cadée and Wesselingh, 2005; Çakirlar, 2009; D'Errico, 1993; D'Errico et al., 1993, 2009; Francis, 1982; Joordens et al., 2014). In addition, microscopic and experimental studies have provided insight into past systems of attachment and degrees of usage (Bonnardin, 2008, 2012; Langley and O'Connor, 2015; Mărgărit, 2016; Taborin, 1993; Vanhaeren and D'Errico, 2003; Vanhaeren et al., 2013). Studies have also demonstrated that shell mechanics and the formation of wear can vary according to the species and its (micro-)structure (Cuenca-Solana et al., 2015; Szabó, 2010; Weston et al., 2015).

The approach used here couples microscopic analysis with experiments in order to assess the technologies, toolkits, and stages involved in the *chaîne opératoire* of ornament production. Technology is regarded as encompassing cultural choices and transmission of knowledge across generations within a same community (Dobres, 2010; Gosselain, 2000; Lemonnier, 1993; Sillar and Tite, 2000). It may involve not only a mental

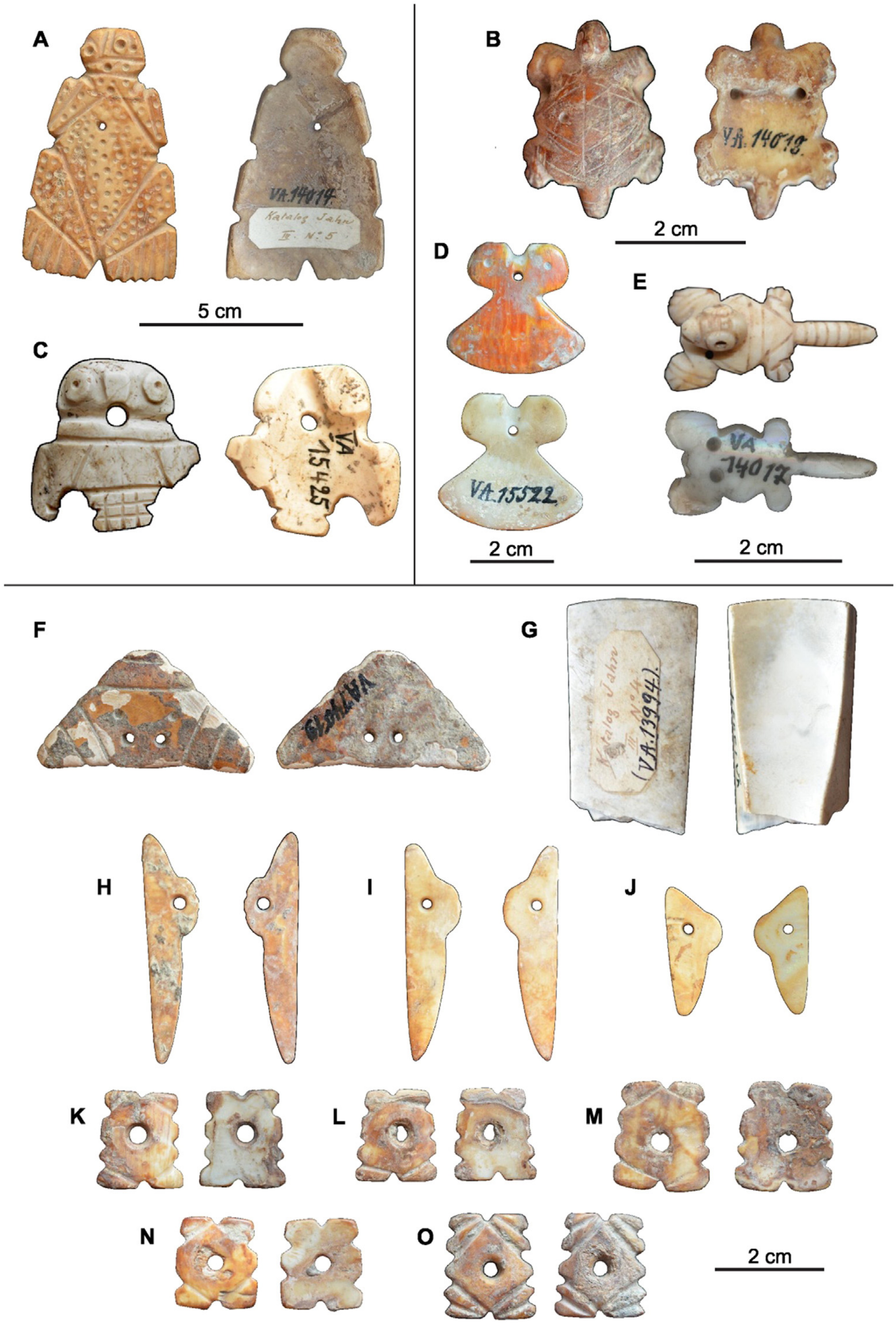

Fig. 2. Shell ornaments from the Alfredo Jahn collection analyzed in this article. Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, (a) VA 14014, (b) VA 14018, (c) VA 15425, (d) VA15522, (e) VA 14017, (f) VA 14019, (g) VA 13994, (h–j) VA 15431 III, II, I, (k–o) VA 14021 I, II, III, IV, V.

template and *savoir-faire* guiding the execution of an activity, but also an active engagement with materials giving room for flexibility and creativity (Leroi-Gourhan, 1993; Pelegrin, 1991, 2005). A Leica M80 Stereomicroscope was used for the observation of traces under low magnifications (7.5 to 64×), together with a Leica MC120HD camera. Grooves, notches, and perforations are indicative of varied production techniques depending on their location, disposition, morphology, and presence of striations. Photographs of entire artefacts were made with a Nikon Digital Camera D5100. For high magnifications (50× to 200×), a Leica DM 6000 m Metallographic microscope was used, equipped with a Leica DFC 450 camera, which can create Z-stack photographs. The analysis involved recording the location, distribution, topography, and directionality of polish and striations (Cuenca-Solana, 2013; Cuenca-Solana et al., 2015; Lammers-Keijsers, 2007). It was focused on evaluating the presence and extent of use-wear and also surface treatments, such as grinding traces. Specific wear patterns on the surfaces were considered as evidence of use: 1) polish and rounding on the rim of perforation; 2) deformation of the rim; 3) scratches

Table 1
Attributes of the analyzed shell ornaments from the Alfredo Jahn collection. Measurements are in mm. I: ink, NP: nail polish, S: labelling sticker, PO: pencil outline, MR: modern residue, SN: stains, E: erosion; Sed: encrusted sediment, OB: old break, FB: fresh break.

Sample id	Taxa	Type	L	W	T	Weight (g)	Perf n°	PDSM	Post-excavt.	Technology				Use	Provenience
										Sawing	Grinding	Polishing	Decoration		
VA14021-I	Spond.	Bead, frog	17	14	1	0.910	1	E, Sed	No	Yes	Yes	No	Inc	Yes	Los Cerritos
VA14021-II	Spond.	Bead, frog	16	15	2	1.030	1	E, Sed	No	Yes	Yes	No	Inc	Yes	Los Cerritos
VA14021-III	Spond.	Bead, frog	19	17	1	0.870	1	E, Sed	No	Yes	Yes	No	Inc	Yes	Los Cerritos
VA14021-IV	Spond.	Bead, frog	16	14	1	0.680	1	E, Sed	No	Yes	Yes	No	Inc	Yes	Los Cerritos
VA14021-V	Spond.	Bead, frog	18	15	2	1.410	1	E, Sed	No	Yes	Yes	No	Inc	Yes	Los Cerritos
VA14018	Spond.	Pend, turtle	33	25	7	7.410	2	E, Sed	I	Yes	Yes	Yes	Inc, Exc, Dril	Hi	Los Cerritos, burial
VA15431-I	Bivalve	Pend, knob	24	10	2	0.830	1	Sed	No	Yes	Yes	No	No	Hi	El Zamuro
VA15431-II	Bivalve	Pend, knob	43	10	2	1.370	1	E, Sed	No	Yes	Yes	No	Yes	Yes	El Zamuro
VA15431-III	Bivalve	Pend, knob	39	10	2	1.330	1	E	No	Yes	Yes	No	Yes	Yes	El Zamuro
VA15522	Spond.	Pend, shell	30	32	3	5.220	1	E	I, NP, PO	Yes	Yes	Yes	Dril	Yes	El Zamuro/Camburito
VA14019	Spond.	Pend, triangle	22	40	2	3.590	2	E, Sed	I	Yes	Yes	No	Inc, dril	Yes	Los Cerritos, burial
VA15425	Lobatus	Pend, owl	49	48	5	31.630	1	OB, Sed	I, NP, PO	Yes	Yes	Yes	Inc, Exc, Dril	Hi	El Zamuro
VA14017	Lobatus	Pend, armadillo	32	16	12	3.000	2	No	I, NP, PO	Yes	Yes	Yes	Inc, Exc, Dril	No	Los Cerritos, burial
VA14014	Spond.	Pend, hybrid	76	46	3	25.220	1	E, Sed	I, NP, S, PO, MR	Yes	Yes	No	Inc, Exc, Dril	No	Los Cerritos, burial
VA13994	Lobatus	Pend, axe	43	22	11	19.820	1	FB, Sed	I, NP, S, SN	No	Yes	No	No	No	La Cabrera

entering the rim of perforation; and 4) polish and rounding on the edges. The presence, distribution, and intensity of these traces provided data regarding the relative length of use.

Interpretation in microwear research works through analogies and inferential leaps whose limits must be acknowledged (Van Gijn, 2010, 2014b). Artefacts undergo several processes that can

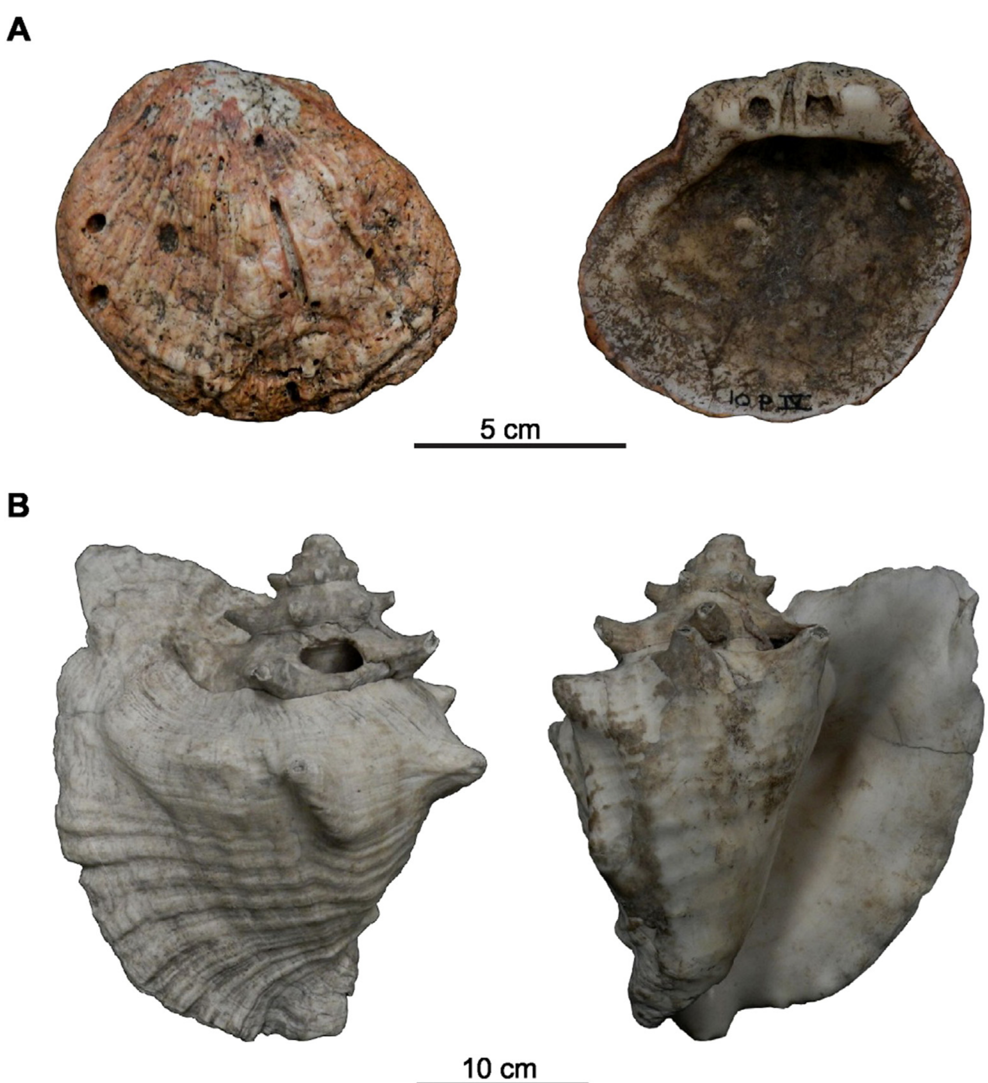

Fig. 3. Shells used in the production of Valencioid ornaments: (a) water worn *Spondylus americanus*, (b) *Lobatus gigas* with a hole made on the apex by a fisherman to remove the animal.

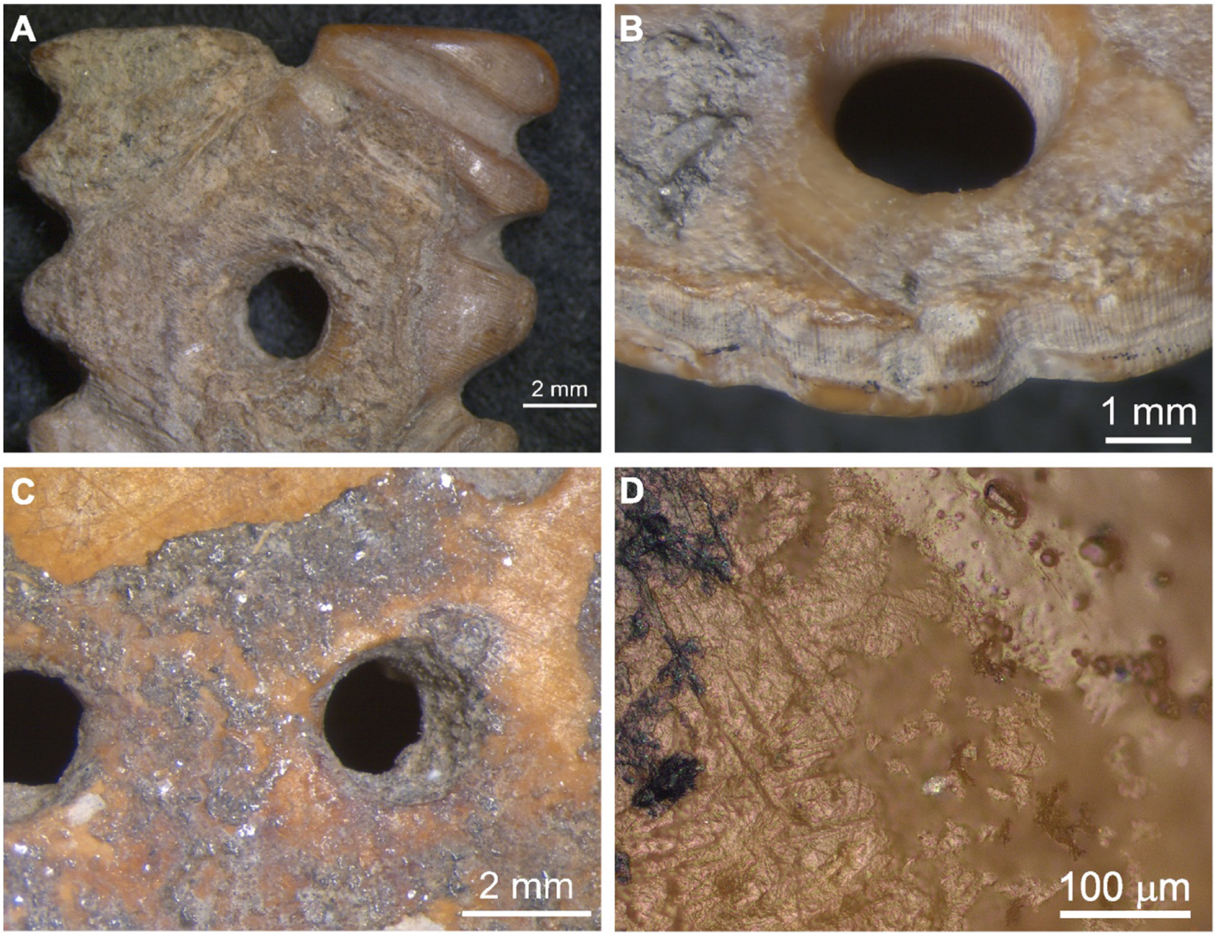

Fig. 4. Post-depositional and post-excavation modifications on the surface of shell ornaments: erosion (a, b, c), encrusted sediment (c), pencil outline (b), ink and nail polish (d). Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 14021 V (a), VA 15431 II (b), VA 14019 (c), VA 14018 (d).

impair the recognition of traces on their surfaces. In addition to the already mentioned post-depositional and curatorial modifications, new traces superpose previous ones, modifying or erasing them during ornament manufacture and use. Experiments reproduce activities in a mechanical and controlled fashion which offers limited comparison to the complex activities that take place in a real social context (Van Gijn, 2014b). In this sense, traces on experimental pieces cannot be taken as replicas of those on archaeological artefacts. The limits of interpretation become clearer in the case of figurative ornaments, whose production involved the application of several techniques in succession, thus requiring high skill and experience. For the present research, it was decided to just reproduce individual techniques, i.e. testing the interaction between certain tools and contact materials, in order to contrast the microscopic traces experimentally generated to the archaeological ones. This somewhat mechanical approach would avoid the issue of our lack of skills and expertise to some extent. Attention was also given to the microstratigraphy of traces on artefacts: this allowed us to assess how the techniques were applied in succession, thus constituting a production sequence.

Table 2
Experiments conducted; slurries used: water (W), sand (S), coral (C).

Exp n°	Blank	Technique	Tool	Slurry	Time	Efficiency
2480	*L. gigas* lip	Percussion	Hammer-stone, wood anvil	No	–	Effective
2484-1	*L. gigas* lip	Grinding	*Acropora palmata*	W	–	Effective
2484-2	*L. gigas* lip	Drilling	Hafted flint palms	No	–	Effective
2486	*L. gigas* lip	Drilling	Bow drill flint	No	–	Effective
2487-1	*L. gigas* lip	Drilling	Hafted G. officinale wood palms	S, W, C	–	Ineffective
2487-2	*L. gigas* lip	Drilling	Mechanical drill wood	S, W	102′55″	Effective
2490-1	*L. gigas* lip	Sawing	Flint blade	No	–	Effective
2500	*L. gigas* lip	Grinding	*A. palmata*	No	24′	Effective
3055-1	*L. gigas* lip	Sawing	Flint	S, W	135′	Effective
3043	*Spondylus* sp.	Sawing	Flint	No	63′	Effective
3045	*Spondylus* sp.	Grinding	*A. palmata*	S, W	35′	Effective
3061-1	*Spondylus* sp.	Percussion	Hammer-stone, wood anvil	No	–	Effective
3061-2	*Spondylus* sp.	Drilling	Mechanical drill bone	S, W	110′	Effective
3062-1	*Spondylus* sp.	Grinding	Sandstone	W	80′	Effective
3062-2	*Spondylus* sp.	Notching	Flint	No	25′	Effective
3062-3	*Spondylus* sp.	Notching	G. officinale wood	S, W	91′	Effective

The main objective of the experimental research was to assess production techniques of *S. americanus* and *L. gigas* ornaments. The choice for toolkits was based on observed archaeological traces, and ethnographic and ethnohistoric descriptions from the Caribbean and lowland South America. Other experiments previously conducted in the Caribbean also served as reference (e.g., Antczak, 1998; Carlson, 1995; De Mille et al., 2008; Lammers-Keijsers, 2007). Our experiments covered different stages of manufacture, including blank acquisition, grinding, decorating, and drilling (Table 2). Whereas hard lithic tools have been found associated to bead-making debitage in some Caribbean sites (Carlson, 1995; Haviser, 1990; Narganes Storde, 1995; Rodríguez, 1991), different sources suggest that wood, bone and cotton strings were probably likewise used for sawing and drilling (Koch-Grünberg, 2005; Las Casas, 1967; Lothrop, 1955; Ribeiro, 1988; Rodríguez Ramos, 2013; Rostain, 2006; Roth, 1924). As grinding platforms, coral slabs made of *Acropora palmata* (Lamarck, 1816) were used in our experiments, as suggested by abundant Caribbean literature and site inventories (Antczak, 1998; Clerc, 1974; Kelly, 2003; Kelly and Van Gijn, 2008; Lammers-Keijsers, 2007; Van Gijn et al., 2008). The results of the experiments will be discussed below (Section 3), where they will be contrasted to traces observed on the Valencia Lake artefacts.

3. Results: production sequence

In the sections below, the different stages, techniques, and tools involved in the *chaîne opératoire* of complex figurative ornaments will be discussed. Potential challenges in the analysis and interpretation will also be highlighted. As we hope to demonstrate, shell ornament technology in the Valencia Lake Basin involved multiple stages, high skill, and good understanding of raw material properties, alongside clear forward planning.

3.1. Blank acquisition

The majority of ornaments were made through sawing and breaking flat blanks from a shell (11; 73,3%), which can be recognized by their flat or convex cross-section with straight or tilted sides. These traits were observed on frog-shaped beads (VA 14021 I-V) and on the shell- (VA 15522), the triangle- (VA14019) and the "knob"-shaped pendants (VA 15431 I-III). Cut marks were left on the sides, although they were often erased by subsequent surface treatments (Fig. 5). The application of this technique involved the sawing of cut grooves, followed by snapping the piece of raw material. Whereas sawing a *Spondylus* sp. shell with flint is quite fast and allows for the production of controlled blanks (exp. 3043), flaking the shell does not easily produce blanks of a desired shape (exp. 3061-1). The choice for sawing could therefore be related to an efficient use of the marine shells given their sparse availability in the Valencia Lake Basin.

In contrast, the pendants made from shells of the *L. gigas* required a preliminary method of blank acquisition. No clear traces from this stage are observed on the ornaments, as their manufacture led to considerable modification of the original blank. Nevertheless, the natural morphology and curvature of the shell, in addition to the presence of nacre and natural irregularities, provide insight into the sectors of the shell from which the blanks were obtained: the lip and the body whorl. Sawing experiments with a flint tool on *L. gigas* showed that the technique is time-consuming and results in constant breakage of the edge of the flint flake (exp. 3055–1). The complex cross-lamellar microstructure of the *L. gigas* shell renders it tough, and alongside its thickness, makes the shell resistant in the natural environment (Kamat et al., 2000). Flaking or breaking the shell is necessary, especially if the primary goal is to separate the lip from the body whorl or to open the whorl (Antczak, 1998). One can also take advantage of the natural layering of the shell to obtain blanks (Suarez, 1981; Vargas Arenas et al., 1997). Antczak (1998, 399–401) demonstrated the varied ways in which the *L. gigas* shell was broken in the islands off the Venezuelan coast for the creation of usable parts to be taken to the Valencia Lake Basin. Knapping operations could be performed using the apex of the shell or a hammerstone, and a slab of *Acropora palmata* or stone as anvil.

3.2. Grinding

In the shaping stage, different techniques were applied in order to render the morphology of the blank closer to that of the desired end-product. Grinding was the most common shaping technique, being used to remove irregularities of the shell, the nacreous layer and to create a smooth surface for carving. The microtopography observed on artefacts, with flat and striated polish predominantly on the tops, suggests the use of mineral hard materials for grinding, possibly stones or corals (Fig. 6a, c, e). The experimental grinding of *L. gigas* shells was time-consuming, especially when compared to *Spondylus* sp. (exp. 3045). The use of sandstone platforms with abrasives generated an intensively flattened microtopography and abundant regular striations on the shells, produced by the grains dislodged from the platform and/or added abrasives (Fig. 6d). Grinding with an *A. palmata* platform was facilitated by the addition of water, due to the formation of a thin abrasive paste by the dislodged coral grains (Breukel, 2013; Kelly, 2003; Lammers-Keijsers, 2007). The *Spondylus* sp. blank ground on coral presented less pronounced flattening and fewer striations, probably related to the lack of coarse abrasives (Fig. 6f), while the *L. gigas* blank presents intense thin striations (Fig. 6b). In this sense, at this stage, it is not possible to distinguish the material used for grinding the archaeological artefacts. Further experiments are required.

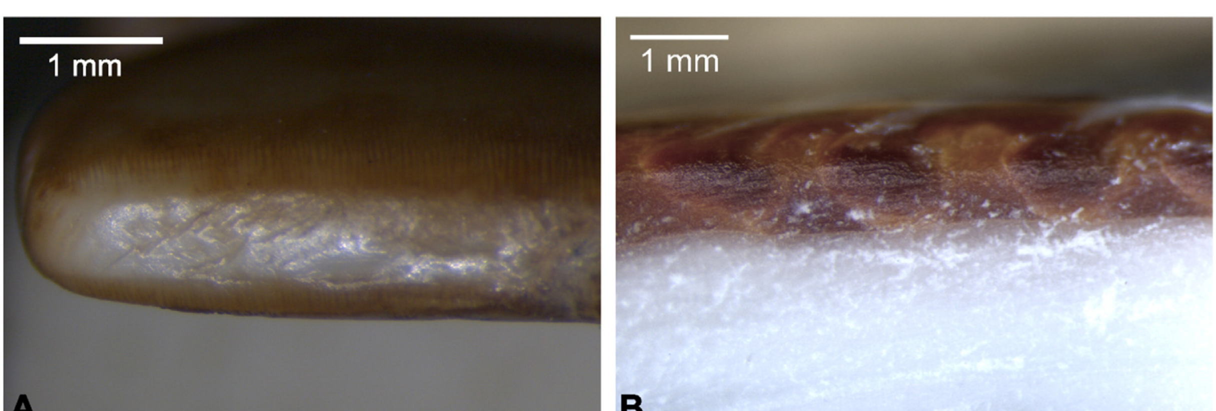

Fig. 5. Partially erased cutting traces on archaeological (a) and experimental (b) shell ornaments. Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 14021 V (a).

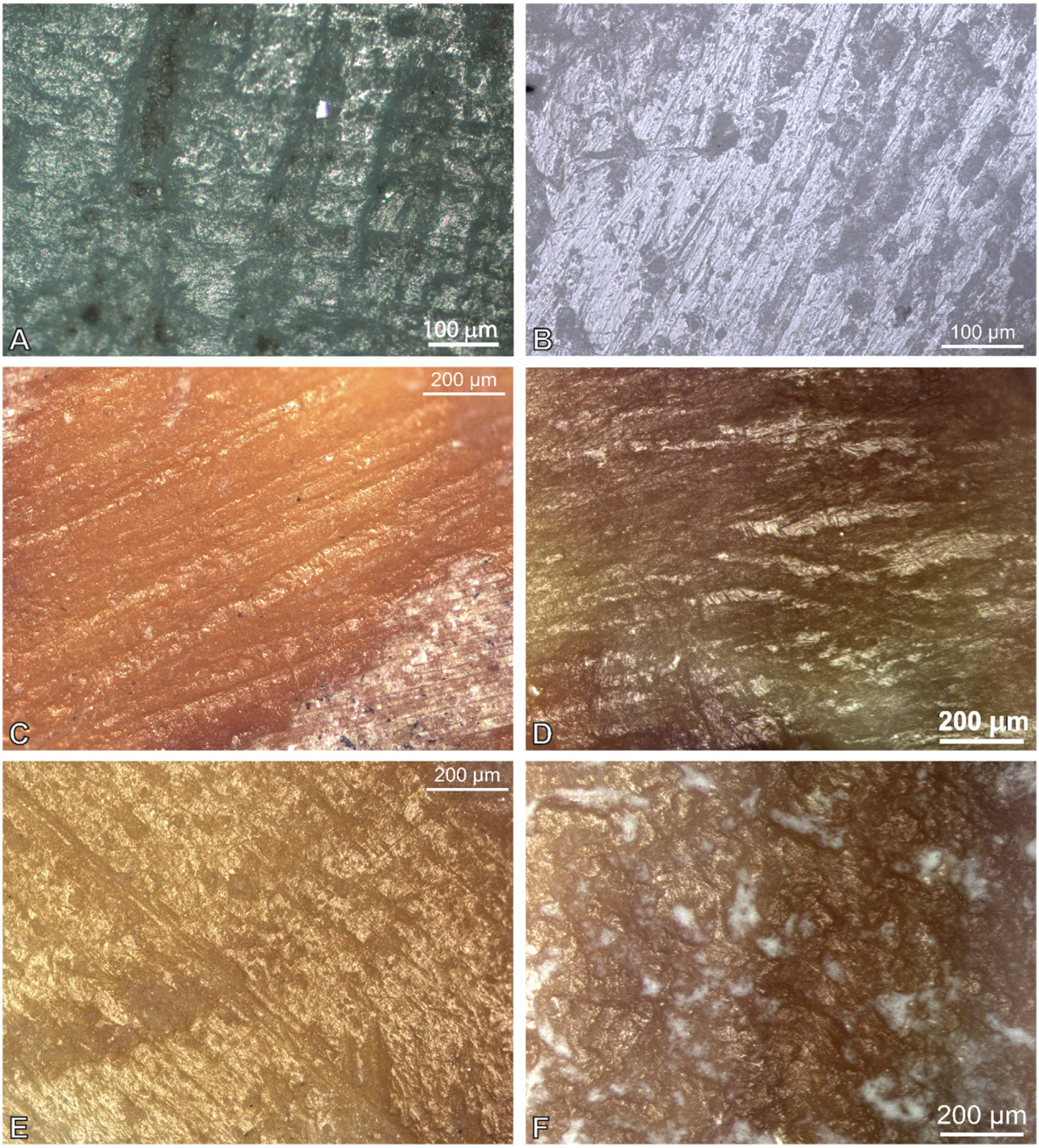

Fig. 6. Archaeological (a, c, e) and experimental (b, d, f) grinding traces. Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 14017 (a), VA 14019 (c), VA 14018 (e).

3.3. Notching and incising

Notches with V-shaped profiles and striations were observed on frog-shaped beads and "knob" pendants (Fig. 7a). These notches could be made by sawing with a hard lithic tool on the side of the artefacts, in order to give the blanks specific figurative designs. After the first cuts in a same position, notches were expanded by the execution of multiple cuts by the same tool in slightly different positions. Both notch the V- and stepped V-shapes were reproduced during the experiments using flint (Fig. 7b). Other notches, observed on *S. americanus* and *L. gigas* biomorphic pendants, have a U-shape and striations (Fig. 7c). These notches may have also been started with a hard lithic tool, but were subsequently widened with a softer tool, for instance wood or bone. It has been argued that, when using soft tools for sawing, slurries must be added as the abrasiveness of the hard grains, carried back-and-forth by the tool's edge, is the active agent, while the water is lubricating and cooling both surfaces in contact (Miller, 2007, 59; Hodges, 1971, 105). In order to reproduce a U-shaped notch on the side of a *Spondylus* sp. shell fragment with a *Guaiacum officinale* wooden flake (Fig. 7d), a preliminary notch had to be made with flint (exp. 3062-3). On archaeological specimens, the notch was produced by first sawing the opposing faces of the shell, before linking the two grooves by sawing the side. During experiments, this proved to be easier than directly sawing the thin side, where there is less support for the edge of the tool.

On the studied ornaments, sawing was also used to add decorative designs or to create morphological patterns on the depicted animals. The technique produced U-shaped incised lines with striations (Fig. 8a–d). The carved lines are generally thicker on the centre of the surface, while they appear thinner closer to the edges of the artefacts. This is a

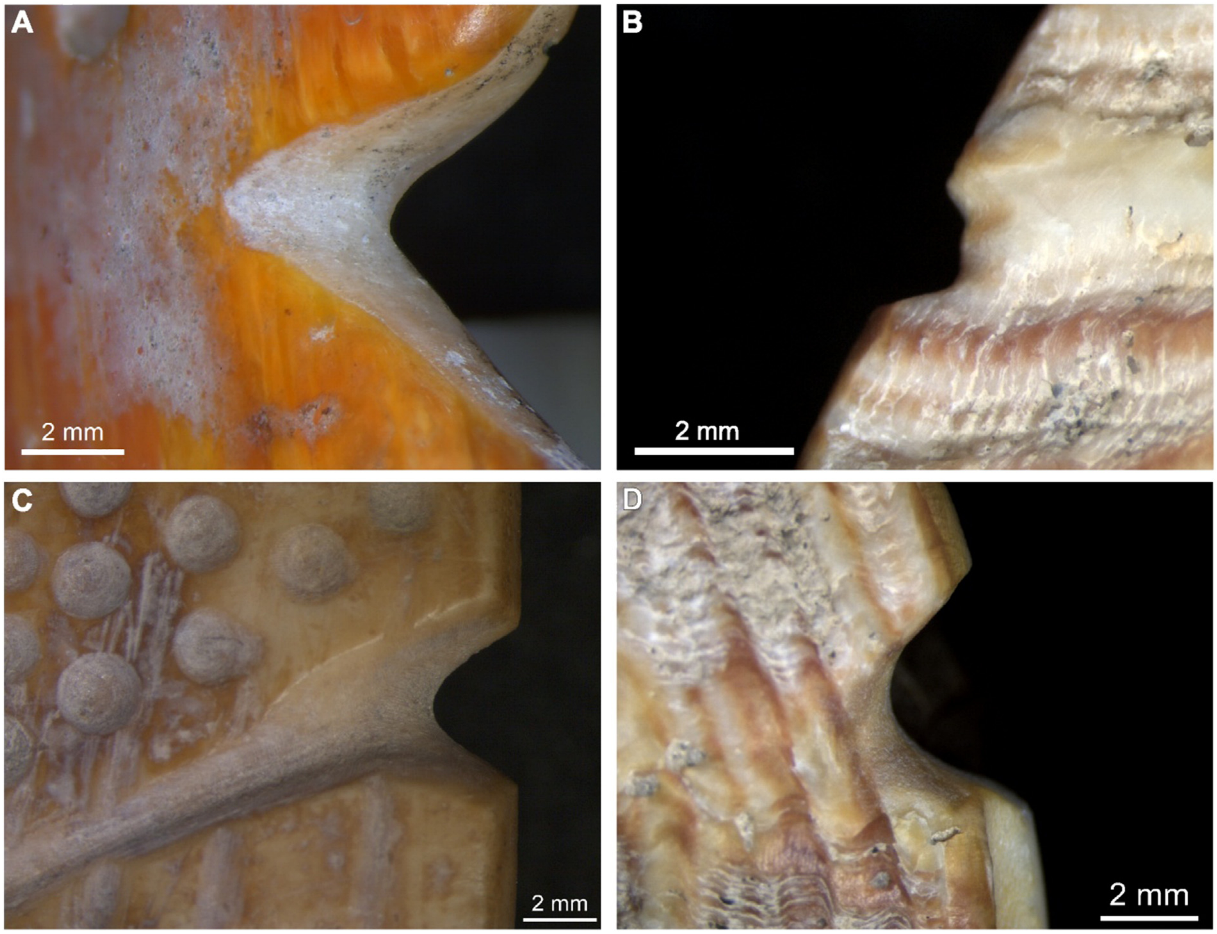

Fig. 7. Archaeological (a, c) and experimental (b, d) side notches. Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 15522 (a) and VA 14014 (c).

result of the sequence of gestures used for sawing: according to the experiments, it is easier to start by sawing the pronounced centre of a convex surface, and only afterwards proceed towards the edges. Therefore, a greater number of cuts are present on the centre, generating a wider and deeper incision groove. The observation of the artefacts shows that side notches were often produced after the decorative incisions. In fact, certain incisions were applied at an early stage of manufacture probably to serve as a sketch of the desired shape, guiding its execution (Fig. 8e). This can be regarded as evidence that the choice for a specific blank is connected to the desire of creating an end-product with a certain shape. For example, morphological features of zoomorphic ornaments were excised through the execution of multiple incisions and notches, isolating an area from the rest of the artefact (Fig. 8f). In this sense, a sufficiently long and thick blank had to be selected for making the armadillo-shaped pendant, so that its head and tail could be separated from the main body. This blank is rather different from the one necessary for the production of, for instance, the turtle-shaped pendant. The maker knew how to manipulate the volumes and properties of each raw material in order to create the desired figures.

3.4. Drilling

Drilling was used to create suspension holes and as a decorating technique, producing dots, eye sockets and mouths on the ornaments. Decorative perforations were not completed, creating just a shallow stepped circle (Figs. 7c, 8c, f). The abundance of this feature on the artefacts shows that their production was not considered risky from a technological point of view. The drilling technique produced suspension holes with similar characteristics in all ornaments, suggesting the use of a specialized massive drill. Features include cone-shaped or cylindrical perforations, a diameter of 2–3 mm, a tapering but relatively flat leading edge, and thick and regular circular furrows (Fig. 9a, b). Perforations were made predominantly from one face and only finished from the other. The exceptions are the perforations in which the two cones are placed in angles close to 90°.

To explore the kind of drill that would produce these features, experiments were conducted using different drilling mechanisms and bits. A handheld flint tool was used to start perforations, so that the drilling devices could be stabilized. While all the experiments with flint proved to be effective, the use of drill bits of organic materials was only efficacious when mounted on a mechanical drill and with addition of sand and water. *G. officinale* wood and mammal bone were used to drill *L. gigas* and *Spondylus* sp. respectively (exp. 2487-2 and 3061-2). Both tasks were time-consuming, but nevertheless efficacious. Depending on the morphology of the drill bit, the perforations were cone-shaped or cylindrical. The micromorphology of the experimental perforation made with wood is closer to the archaeological ones, including a tapering cylindrical shape, furrows, and a flattened leading edge (Fig. 9c, d). The furrows are quite regular in shape, in contrast to those experimentally obtained by working with a flint drill bit. They could have been caused both by accumulations of abrasive powder and debris and by the wearing of the wood, which makes the edge blunt and larger. More experiments need to be carried out to test this hypothesis.

3.5. Polishing

The presence of modern additions to the surface of some ornaments prevented a detailed analysis of the polish on a number of cases. Many

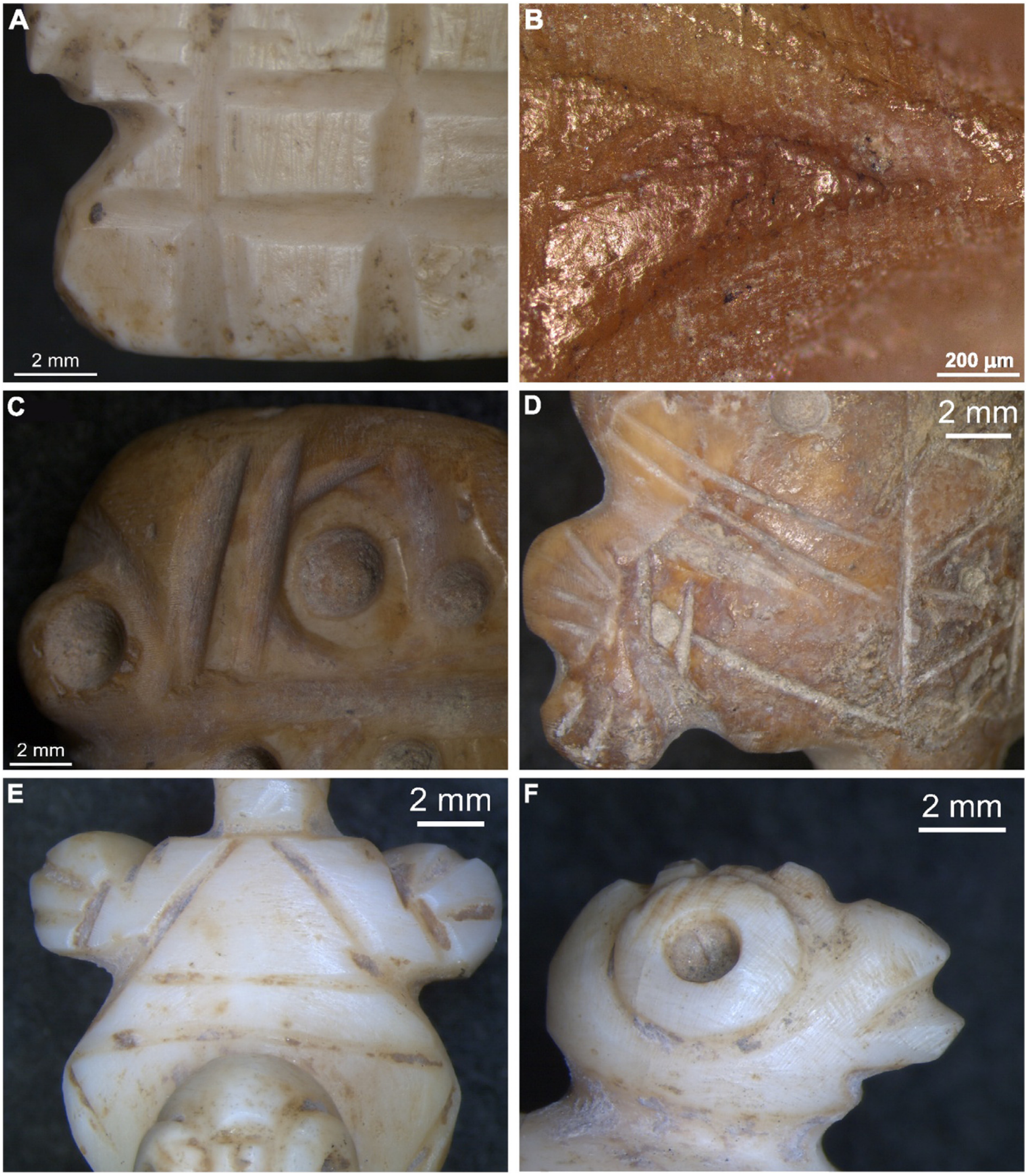

Fig. 8. Decorating techniques: incision (a–e), excision (f), and unfinished perforations (c, f). Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 15425 (a), VA 14014 (b, c), VA 14018 (d), VA 14017 (e, f).

artefacts had a rounded appearance and polish along the edges, which is likely connected to continuous use (see Section 4). The presence of a polishing stage, understood as a surface treatment designed to smoothen the artefacts' surfaces, alongside giving it sheen, was only possible to ascertain on few artefacts. It was used for the zoomorphic ornaments, where traces from the preceding production stages were intentionally smoothened. A soft and malleable material was rubbed on low areas of the artefacts in order to erase cut marks from notching and excising. These low-lying areas would not be in direct contact with the skin during use. However, the abundance of misplaced cut marks on the figurative ornaments suggests that, in comparison to the extent of the grinding stage, the effort put into polishing was minimal. The technique was also used for giving certain features a more rounded appearance.

4. Results: use-wear

Most shell ornaments display evidence for having been used (12; 80%), often in the form of polish and rounding on the rim of perforation (6; 40%) (Fig. 10). These traces are produced by friction of the string on the rim of perforation during attachment and by the presence of body fluids (Vanhaeren et al., 2013). On one pendant, scratches entering the rim were observed, probably caused by the abrasive nature of the string

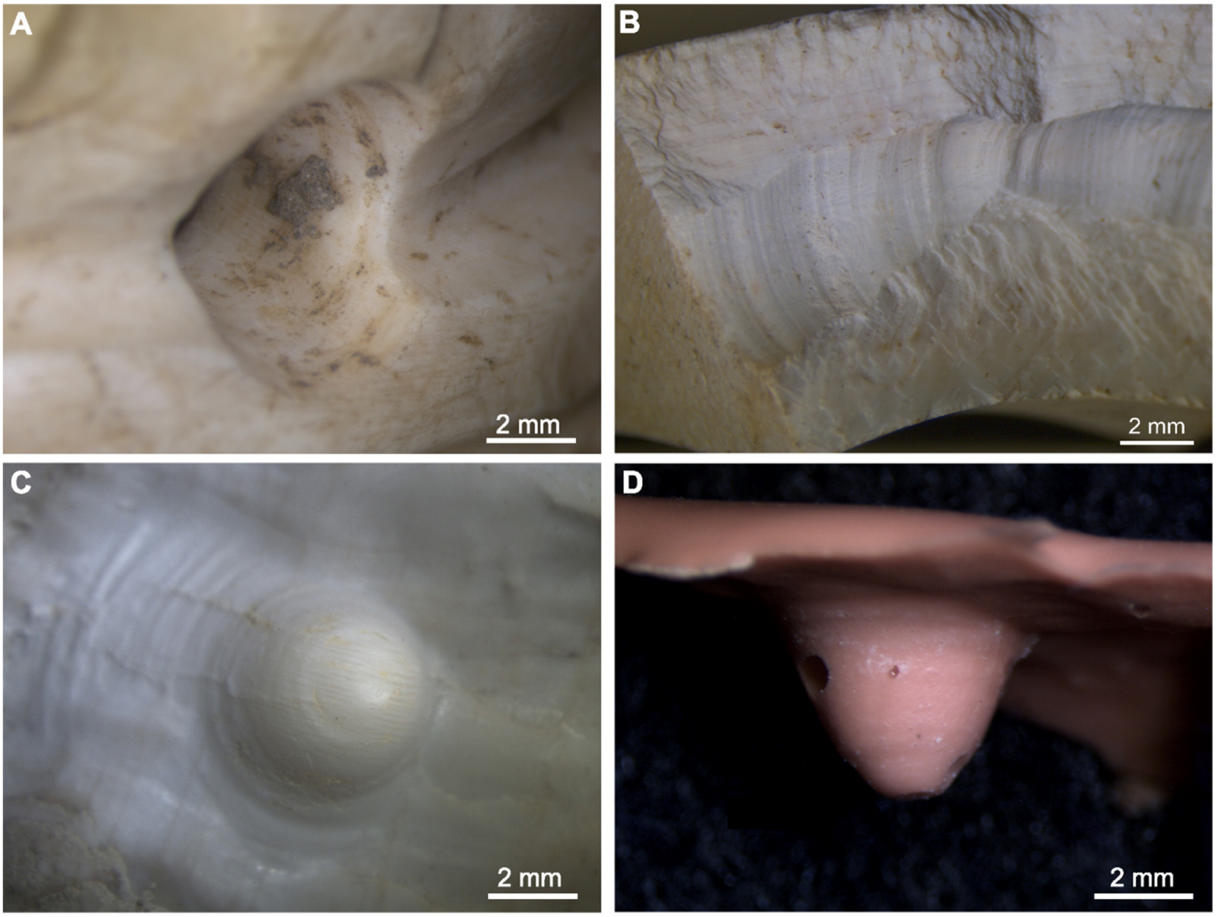

Fig. 9. Holes produced by drilling on *Lobatus gigas* shell: detail of the holes on VA 15425 (a) and VA 13994 (b). Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz. Hole experimentally produced with a *Guiacum officinale* tip (c) and its cast made with polyvinylsiloxane (d).

material, as in the case of siliceous plants (Fig. 10a, b). Deformation of the rim of perforation was noted on seven artefacts (46,7%), being probably connected to long-term usage of the ornament (Fig. 10c, e). The association of deformed grooves and scratches with the use polish allows for a clear differentiation from deliberate cut marks. Contact with the human body and/or clothing caused a distinctive polish around the edges of artefacts on the non-decorated, concave faces ($n = 7$) and on both faces ($n = 3$). Three artefacts do not display use-wear traces. Post-depositional surface modifications affected the interpretation of some artefacts, whenever they underwent breakage, extensive erosion of the rim, and sediment encrustation. On the concave surfaces, the remains of nacre, alongside nail polish and ink, impaired interpretation. No residues that could have been used to attach the ornaments, such as adhesives or gums, have been observed on the artefacts. The interpretation of any potential residue as archaeological is also considered problematic due to the long post-excavation trajectory of the collection.

The two perforations at angles of approximately 90° on the sides observed on two studied pendants (VA 14018 and VA 14017) are also typical of the Amazonian *muiraquitãs*; it has been suggested that they were related to a specific system of attachment, different from just hanging the artefact on a necklace (Barata, 1954; Gomes, 2001; Moraes et al., 2014). Similarly, size and weight must have been relevant in the placement of ornaments, as larger artefacts were potentially placed in positions of notice (e.g., on the centre front, on the back or on the sides). Most zoomorphic pendants display highly developed traces on these zones. The combination of the different use-wear traces on each artefact suggests that they were in fact woven into a composition. For instance, the owl-shaped pendant probably had strings attached from the sides and through the mouth (Fig. 10e, f). The turtle-shaped pendant was likely attached with a single string passing along the width of the artefact, but with knots on the end of each perforation in order to keep the pendant in place (Fig. 10g, h).

In relation to the asymmetric and geometric specimens, deformation was clearly observed on the “knob” pendants, which displayed grooves on both faces, extending from the perforation to one of the edges of the artefacts (Fig. 10d). The grooves were caused by use and are indicative of strings being tied on both sides of the pendant. They were probably kept in place by multiple strings (or the same one passing inside the hole more than once), which attached it to a fixed position on a band. The shell-shaped pendant had a similar system of attachment, but the visible part would be the coloured face, rather than the side. In the frog-shaped beads, the erosion of the perforation area prevented an interpretation of the systems of attachment.

5. Discussion and conclusion

Microscopic analysis of ornaments has developed into an established field of studies over the past 20 years (Moro Abadía and Nowell, 2015; White, 2007). In the present article, we expand this method to a region where it has seldom been applied, i.e. the circum-Caribbean (see also Falci, 2015). By displaying complex and varied shapes, the Venezuelan collections studied here pose new questions for the field. We identified three challenges regarding the nature of these collections that require a critical approach to interpretation: 1) the conditions of preservation, 2) the complexity of the three-dimensional artefact shapes and our limitations in replicating them, and 3) the varied ways in which the artefacts may have been used. These will be further discussed below.

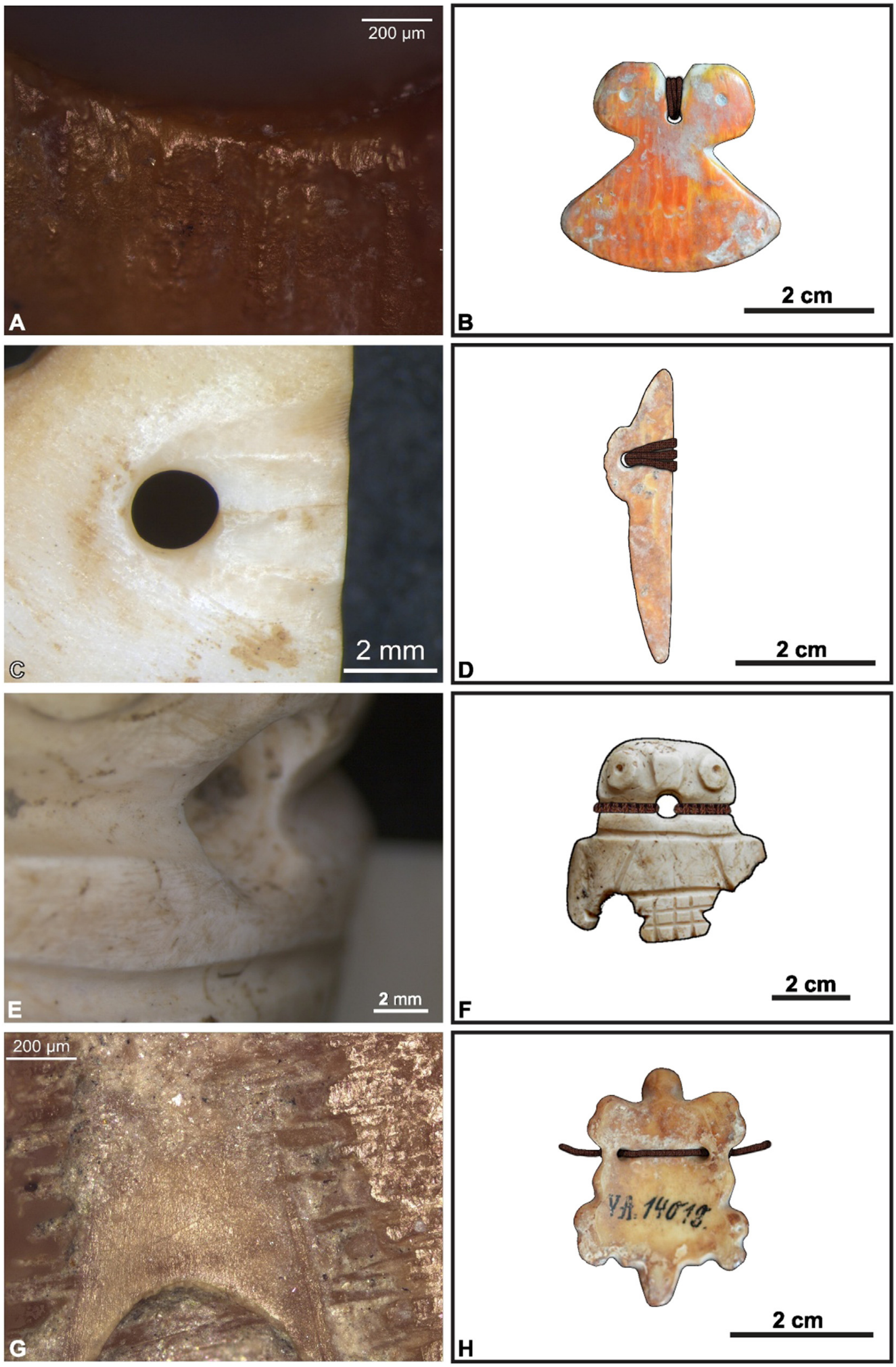

Fig. 10. Use-wear traces on shell ornaments (a, c, e, g) and potential attachment systems (b, d, f, h). Staatliche Museen zu Berlin - Ethnologisches Museum, Preußischer Kulturbesitz, VA 15522 (a, b), VA 15431 I (c), VA 15431 III (d), VA 15425 (e, f), VA 14018 (g, h).

The state of preservation of the artefacts that make part of museum collections was the first challenge dealt with. Post-depositional and curatorial surface modifications cannot be ignored, as analysis and interpretation of a number of specimens is impaired. The great variability in types in the assemblage, alongside modern surface modifications, limited analysis to low power stereomicroscopy. Nevertheless, a careful examination of most artefacts under varying magnifications, alongside an experimental programme, allowed a range of conclusions to be drawn in relation to the production and use of these complex figurative ornaments.

The microwear method, for its focus on individual artefacts, proved to be particularly useful in understanding complex biographies. At the same time, it provided insight into the local tradition in ornament making. In this sense, despite the variety of shapes, the same basic techniques were used, involving a combination of hard stone tools to start knapping, incising, sawing, and drilling, and softer materials to widen the features produced. The microstratigraphy of traces on individual ornaments points to a systematic and recurring sequence in which the techniques were applied. This evidence, alongside the choice for specific shell parts for the production of certain shapes, suggests the existence of a common technological system and mental templates guiding manufacture. The three-dimensional shapes of the ornaments and the lack of technical errors are evidence of the high craftsmanship involved in shell working. Future research on Valencioid collections is necessary to provide further insights into the topic of craft specialization in the production of complex figurative ornaments and its relation to increasing social complexity in the Valencia Lake Basin.

Regarding the experimental programme, the choice for replicating only certain techniques and toolkits, instead of entire production sequences, provided an appropriate reference collection. However, the superposition of different surface treatments and the toolkits used for these purposes also require more extensive research. The performance of several techniques in a sequence in order to produce complex figurative shapes can only be better understood with further experiments in collaboration with skilled artisans.

In relation to use-wear traces, there is a gap between systems of attachment of individual artefacts and actual composite ornaments. Our preconceptions regarding how ornaments were used in the past can lead to biased analysis and interpretation (Frieman, 2012; Van Gijn, 2010, 2014a). On a practical level, these assumptions may result in exclusive attention to areas on ornaments where traces are expected (i.e. rim of perforation and edges) and in overlooking artefacts which are not typologically categorized as ornaments. In broader terms, the very idea that composite ornaments would have been constituted solely by a string, beads of a single type and a pendant is misleading. While further interpretation of the position of individual beads and pendants in composite pieces is hampered by different preservation rates of materials in the archaeological record, drawing a linkage between use-wear traces and actual ethnographic artefacts (e.g., necklaces, bands and clothing items) can provide fruitful insights (e.g., Bonnardin, 2008; Cristiani et al., 2014, 2016; Langley and O'Connor, 2015).

Ethnographic and early historic composite ornaments belonging to indigenous communities from the lowlands of South America involve a range of raw materials, such as seed or glass beads, nuts, bird feathers, stones, metal sheets, animal parts, and plastic (Ribeiro, 1986; Ribeiro, 1988). However, figurative ornaments are not common. Whilst necklaces with carved animal figures of *tucum* nut (*Astrocaryum* sp.) are made by the Tukúna and Mehináku peoples (Ribeiro, 1988, 167), the *tucum* pendants are small and light-weighted and, therefore, not comparable to the pendants studied here. The other known example is of a figurative pendant of polished black stone, which was added to belts and necklaces made of shell disc beads by communities in the Upper Xingu (Hartmann, 1986, 190; Ribeiro, 1988, 160). While different types of attachment were present, they all involved the stone pendants being suspended from a string. Conversely, the use-wear evidence suggests that the large figurative pendants (VA14018 and VA15425) were integrated in woven bands, rather than suspended from a string. Freshwater and land snail shell ornaments are recurrent among some communities in southern Amazonia and central Brazil as necklace pieces, but are generally light-weighted and display simple geometric shapes (Ribeiro, 1988). The shell-shaped pendant (VA15522) may have been part of similar necklaces. The attachment system seen on the "knob" pendants (VA15431) is comparable to necklaces and crowns with jaguar claws found in the Upper Xingu and among the Borôro (Ribeiro, 1988, 166–69). The claws are tied in a band so that the sharp tip of the claws faces upwards. In the future, a systematic comparison with indigenous ornaments from the South American lowlands will be made by generating microscopic data from ethnographic specimens.

Lapidary industries have gained considerable attention in circum-Caribbean archaeology in the last decades, as they play an important role in accounts of the Caribbean as a hub of intense indigenous mobility and interaction (Boomert, 1987; Cody, 1991; Hofman et al., 2007, 2014a, 2014b; Serrand and Cummings, 2014; Watters, 1997). Nevertheless, the majority of research has focused on rock identification and typo-technological studies. As a result, the toolkits used in the production of ornaments of varied types and raw materials are unknown; likewise, little is known regarding the extent to which there would have been specialization in their production. Future microwear research on other collections can provide a better understanding of the biographies of ornaments in the circum-Caribbean. Despite the challenges these artefacts may pose to microwear analysis, they should be further studied due to their varied nature in terms of raw materials, designs, and the skill involved in their production.

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