KEYWORDS: *Petroglyph – Technique – Technology – Hunter-gatherer – Agrarian community*

ROCK ART, TECHNIQUE AND TECHNOLOGY: AN EXPLORATORY STUDY OF HUNTER-GATHERER AND AGRARIAN COMMUNITIES IN PRE-HISPANIC CHILE (500 TO 1450 CE)

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Abstract. Technology is one of rock art's less explored dimensions, especially petroglyph technology. In this paper we approach the technical dimension of petroglyphs by examining a specific set of formal and metric attributes of their grooves. We apply this approach to the petroglyphs of two styles of rock art found in north-central Chile, one related to hunter-gatherer communities (500–1000 CE), the other to agrarian communities (1000–1540 CE). Our results reveal differences between the technologies used by hunter-gatherers to produce rock art and those used by agrarian societies that are coherent with their distinct social lives. Specifically, we recognise differences in the chaines operatoires that are related to different dynamics of settlement patterns, spatial scales of information flow and the size of each community.

Introduction

Like any material product resulting from human labour, rock art is a technology that is deployed within particular social, economic and historic contexts. While the literature abounds with works that discuss technical procedures used to manufacture rock art, especially paintings (Rowe 2001), less attention has been paid to the techniques associated with producing petroglyphs and how these are integrated into the social milieus of which they are a part.

Studies of petroglyphs conducted to date have focused on describing the attributes of the instruments used, their traces of wear, and the time invested in this labour. While such studies date back as early as the late 19th century (McGuire 1891, 1892), with additional contributions coming more recently (Sierts 1968; Bard and Busby 1974; Pilles 1975; Busby et al. 1978), in the past two decades the topic has been more systematically and intensively addressed in replication studies of cupules and other petroglyphs (Álvarez and Fiore 1995; Bednarik 1998, 2001, 2008; Whittaker et al. 2000; Álvarez et al. 2001; Keyser 2007; Méndez 2008; Krishna and Kumar 2010–2011; Kumar and Prajapati 2010; Kumar and Krishna 2014). Less research has been conducted into grooves and the operative sequences involved in manufacturing petroglyphs (Fiore 1996, 2007; Valenzuela 2007; Vergara 2009, 2013). All such works have sought to address one of the less explored dimensions of this materiality and to build a body of information to systematise our knowledge of this aspect of petroglyphs by employing objective approaches and terminology.

While building a systematic knowledge about the instruments and indicators linked to petroglyph manufacture is an essential aspect of rock art studies (Bednarik 1994, 1998, 2001), it also offers a window into understanding and elucidating other aspects linked to the social dynamics and productive processes of pre-Historic societies (Fiore 1996, 2007; Whittaker et al. 2000). Nevertheless, the social implications of the technical attributes and productive processes associated with petroglyphs remain relatively unexplored.

In effect, the technological aspects of material objects are deeply rooted in the social and cultural dynamics of the communities that produce them (i.e. Mauss 1936; Leroi-Gourhan 1971; Lemonnier 1986, 1992; Verbeek 2005), and thus studying them serves to broaden our understanding of human societies. It therefore follows that understanding the technological dynamics of a given materiality does not involve merely identifying the types of instruments and procedures used to manufacture it, but also encompasses the spatial, phenomenological and historical context in which that materiality is produced. Such an analysis relies on the separation, employed in the field of anthropology, between techniques and technologies (Lemonnier 1986; Sigant 1994; Schlanger 2005, 2006). Techniques include the set of procedures and instruments used

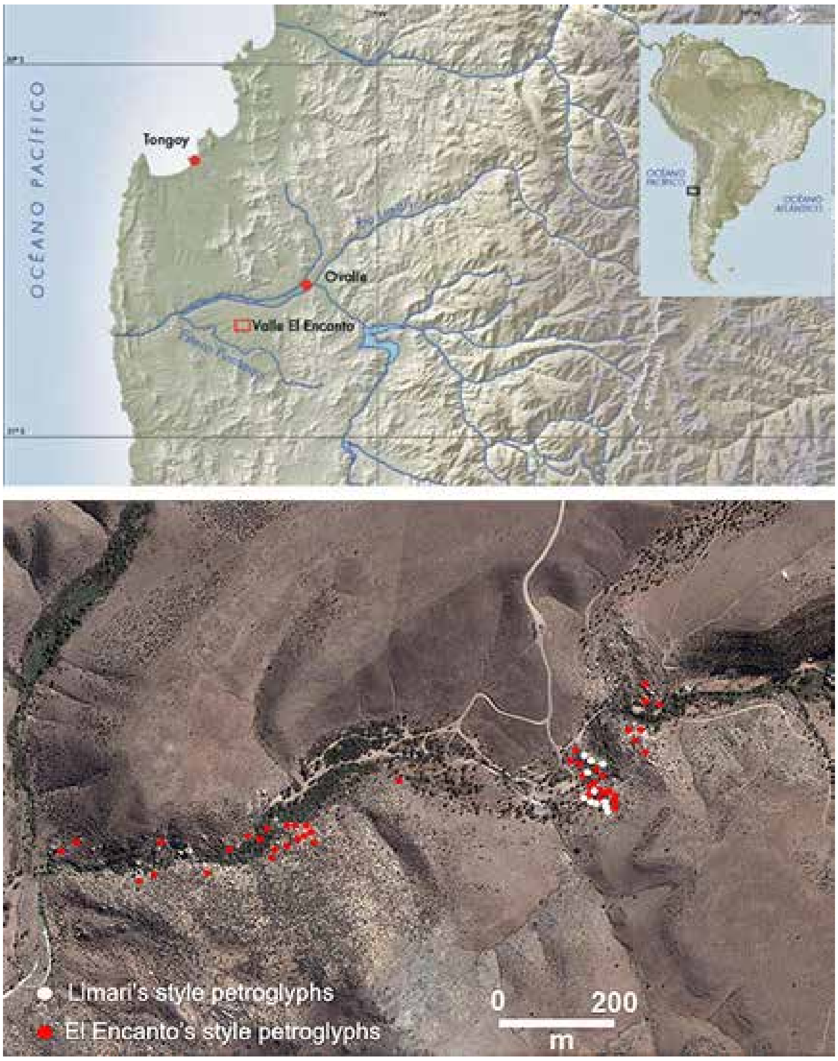

Figure 1. *Map of the area of study and rock engraved in Valle El Encanto, Chile.*

to manufacture an object, or in Mauss's words (1936), 'traditional actions combined in order to produce a mechanical, physical or chemical effect'. In contrast, technology refers to a broader dimension that has to do with the cognitive, symbolic, cultural and social aspects of the manufacturing actions (Lemonnier 1986; Sigant 1994; Schlanger 2006).

Rock art is no exception in this respect, and it is therefore essential to understand the forms, dynamics and implications of its productive process. In light of the above, our study explores the links between the technical attributes of petroglyphs and the social dynamics of their production in the Limarí valley of north-central Chile, in order to understand the technologies associated with the manufacturing of petroglyphs by two types of communities. By characterising and comparing the technologies involved in the production of rock art in hunter-gatherer and agrarian communities, we can evaluate their differences and their relation to the respective communities' social dynamics.

This approach was initially applied in Valle del Encanto, an extensive rock art site located in the Limarí valley (30° lat. S) and one of the best-known in Chile (Fig. 1). This site has been used as a reference point in the elaboration of chronological and stylistic sequences for rock art in the region (Mostny and Niemeyer 1983; Castillo 1985; Troncoso et al. 2008), and it is the only site containing the different techniques identified in the region and the only one with rock art produced by both hunter-gatherer and agrarian societies.

Technique and technology in rock art

The procedures and instruments (techniques) that governed the manufacture of petroglyphs has been explored in replication studies conducted in regions with independent rock art traditions (McGuire 1891, 1892; Bard and Busby 1974; Pilles 1976; Bednarik 1994, 1998, 2001, 2008; Álvarez and Fiore 1995; Álvarez et al. 2001; Mendez 2008; Vergara 2009, 2013; Krishna and Kumar 2010–2011; Kumar and Prajapati 2010; Kumar and Krishna 2014), as well as in theoretical discussions of such procedures (Bednarik 1994, 1998, 2001; Fiore 1996, 2007; Valenzuela 2007).

The bulk of these works have focused on characterising the implements used to produce petroglyphs. From the earliest explorations conducted by McGuire (1891) to the most recent systematic studies of Bednarik (1998, 2001), the performance and nature of these instruments has been examined, as well as the traces of the act of petroglyph production. In all cases, researchers have recognised the greater use and effectiveness of direct over indirect percussion, owing to the latter's technical challenges (Bednarik 1998, 2001; Whittaker et al. 2000), and the former author has pointed to the lack of evidence of the reiterated use of indirect percussion in rock art around the world.

In turn, based on replication studies and research in archaeological contexts, different authors have suggested that the petroglyphs were created with simple instruments, many of which were simply rocks or cobbles with sharpened edges (Sierts 1968; Pilles 1975; Bednarik 1998, 2001; Whittaker et al. 2000). This has hindered their identification in the archaeological record (Bednarik 1998, 2001), although some traces of wear have been identified and described (Álvarez and Fiore 1995, 2001). Bednarik (1998, 2001) has proposed calling these instruments 'mur-e', as they have similar attributes, and has outlined some typical traces of wear.

Less common are studies aimed at assessing the efficiency and time investment associated with manufacturing petroglyphs on different supports (Bednarik 1998, 2008; Whittaker et al. 2000), especially those that recognise the wide variation in outcomes based on the kind of rock that is struck and the raw material used to make the instruments (Bednarik 1998, 2001).

These approaches have enabled us to delve into the techniques associated with manufacturing petroglyphs. However, they have not striven to comprehend the technology used to produce rock art as part of a historic, social and cultural context, situating our understanding of the techniques used within a specific social milieu (exceptions are Fiore 1996, 2007). In effect, while authors have considered the contexts associated with rock art production in order to understand rock art itself (e.g. Lewis-Williams 1995; Ouzman 2001), they have focused exclusively on paintings and their studies have not considered the technical aspect of the manufacturing process.

In this work, therefore, we shall study the techniques used to produce petroglyphs in order to understand the social, historical and cultural aspects of the technology used in two contrasting socio-economic contexts of north-central Chile: hunter-gatherer groups and agricultural ones. As the technologies are deeply rooted in the social and cultural dynamics of the communities that produced them, we expect to find different productive dynamics in these two contexts that reflect their different social dynamics.

Indeed, approaching petroglyphs from a technological perspective provides avenues for enhancing our knowledge of this materiality and its relationship to social life. As with any object produced through human labour, rock art is a product of the decisions and choices made by its producers (Leroi-Gourhan 1971), as has been shown in replication studies that discuss the relationships established between the raw materials of the instruments and the hardness of the engraved rock (Bednarik 1998, 2001, 2008: 86–89). However, such decisions are not made in isolation but are influenced by symbolic, social and cultural concerns and are implemented through a particular productive sequence and within particular spatial, phenomenological and historical contexts (Mauss 1936; Leroi-Gourhan 1971; Lemonnier 1986; Pfaffenberger 1988). In effect, as Mauss (1936) proposed early on, a society's technical procedures are intimately linked to the ways in which members of the social group used their bodies, and to the social and symbolic systems operating in that society. For Leroi-Gourhan (1971), the process of acting on a material is dependent on choices related not only to the attributes of the material, but to the social milieu in which those choices are made. This idea has been extensively advanced in recent decades by several different authors who have emphasised the need to understand the articulation between techniques and the symbolic and social systems operating in communities (Lemmonier 1986, 1992; Pfaffenberger 1988; Dobres 2000; Schlanger 2005).

The particular engagements established between these aspects are relevant because, as Fiore (2007) states for the case of rock art and other authors affirm for technology in general (Lemmonier 1986; Gow 1999; Schlanger 2005), they influence the function and meaning of those objects. In other words, the processes and contexts related to the transformation of a material partially define the meaning and social value of the materiality in a given context (see for example Lewis-Williams 1995; Ouzman 2001). Thus, technology came to be seen as a more complex process that could above all enable researchers to analyse the links between the production-consumption of material culture, social life and the ways in which production is experienced and articulated with other phenomenic fields. Technique therefore offers a window into understanding technology, but it must also be seen as part of the spaces, phenomenological contexts and social milieu associated with manufacturing.

In this approach to technique we use the grooves of the petroglyphs as a unit of analysis. Grooves are always present in the archaeological record and retain relevant information about the production of petroglyphs. In this way they differ from instruments used to manufacture them, which are scarce in the region's archaeological record and have other limitations, as Bednarik (1998, 2001) has pointed out.

While some authors have noted that petroglyph grooves vary in their metrics according to the instrument used to make them (Bednarik 1998, 2001; Whittaker et al. 2000), this attribute has not been used to assess the typical techniques used to manufacture the petroglyphs.

Through a replication study conducted on granitic rock with stone instruments made of andesite (n=75 replications), a raw material that occurs in the zone and was used in the past to manufacture instruments for the production of petroglyphs in the region (Méndez 2008; Vergara 2009, 2013), we proposed two levels of groove analysis, each with their own attributes: (i) a macro level that corresponds to the mark of the groove, and (ii) a micro level, or the negative scar of each strike (Vergara 2009).

The experiments included the production of linear motifs of 10 cm in length and 2 to 4 cm wide, depending on whether or not the figure was filled in. Motifs were made for every possible combination of techniques, types of marks and instruments. All these experiments were performed by the same person.

In terms of the techniques, three classes were differentiated: direct pecking (n=31), scratching (n=28) and a combination of both (n=16). Instruments with pointed and rounded edges (n=38/37 respectively) were used, none of which were formalised, and the raw materials used were igneous rocks with coarse grains, specifically andesite, which is a fine-grained igneous rock predominant in the area, distributed on terraces,

Technique	Tool	Angle of impact	Edge of fracture		Type of surface		Volume in mm³	Total replications	Groove marks analysed
			Circular	Lineal	Rough	Smooth			
Direct Pecking	Rounded edges	180	24	0	24	0	2.59	6	24
		90	44	0	44	0	2.56	11	44
	Pointed edges	180	4	8	12	0	2.43	3	12
		90	44	0	44	0	2.51	11	44
Scratching	Rounded edges	180	16	20	0	36	1.34	9	36
		90	0	12	0	12	0.89	3	12
	Pointed edges	180	0	52	0	52	1.42	13	52
		90	0	12	0	12	0.31	3	12
Combination	Rounded edges	180–90	12	20	12	20	2.94	8	32
	Pointed edges	180–90	4	28	12	20	2.03	8	32
							Total	75	300

Table 1. *Results obtained from replicative studies.*

mountains and river beds. Although it is not a good raw material to manufacture formal instruments, due to its accessibility and hardness it was frequently used in the past to make instruments for rock art production in the region (Méndez 2008; Vergara 2009, 2013). Strokes on the rock were segregated into three types according to the angle of impact: 90°–135° (n=28), 136°–180° (n=31) and a mixed use of both (n=16). Both types covered the range of possible positions to engrave a rock. For each replication we analysed four grooves marks. As a result, 300 grooves marks were analysed (Table 1).

For the group of instruments with rounded borders, length varies between 7.5 and 12.5 cm, while the weight varies between 334 and 407 g. Instruments with angular borders have lengths between 7 and 10.3 cm and they weigh between 108 and 305 g. As previously noted, none of the instruments was formalised, thus they can be classified as unmodified clasts. The experiments were executed on granite surfaces, rock which was used by pre-Hispanic artists.

Replication studies allow us to recognise some variables and attributes in the grooves, related to the quantity of strokes, angles and types of instruments used. On the macro level, four relevant variables have been identified: (i) the continuity or discontinuity of the mark, (ii) the total length of the mark engraved during the manufacture of the petroglyph, (iii) the degree of variability in the groove's width, and (iv) the depth of the groove (Vergara 2009) (Fig. 2). These attributes cover different aspects of production dynamics, with the amount of time and energy invested being one of the most relevant, as it reflects the intensity with which

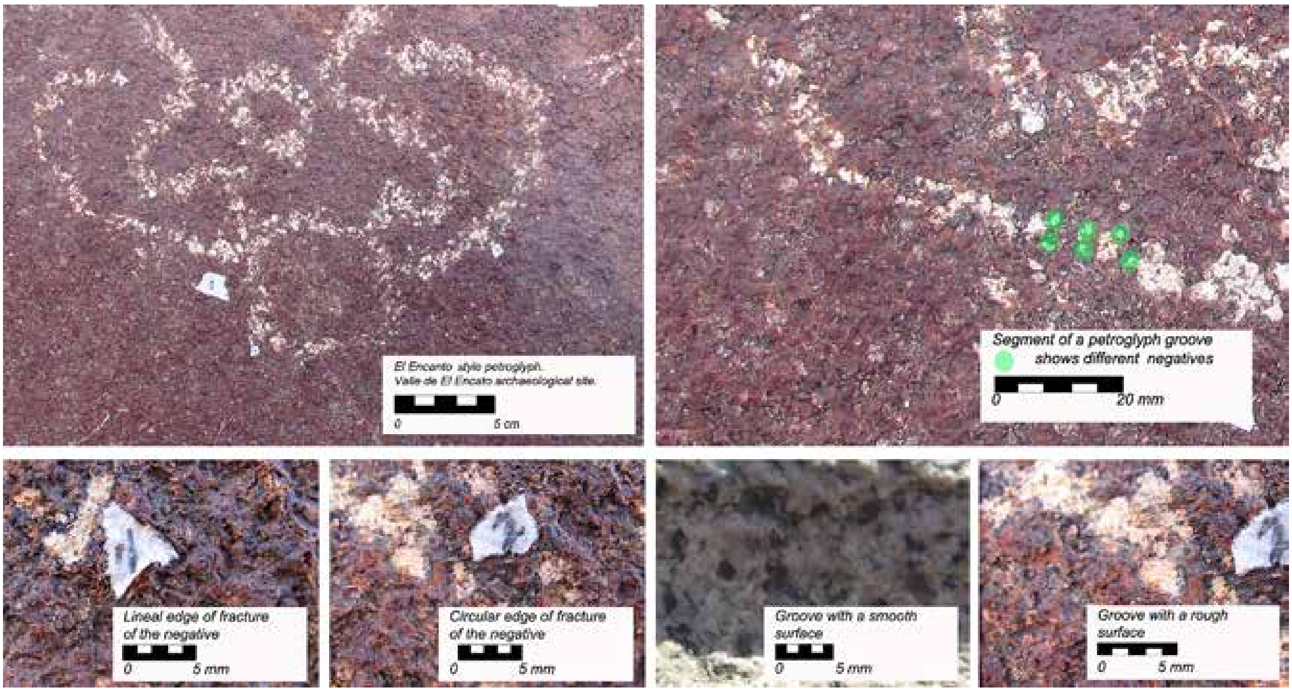

Figure 2. *Rock art attributes related to technology, following our replicative studies.*

the rock surface was modified. This is also related to the raw material used to make the petroglyph instrument, which by definition should be harder than the support (Bednarik 1998, 2001, 2008).

At the micro level, we distinguish: (i) the presence or absence of cortex on the inside of the mark, (ii) the edge of the fracture of the negative scar, (iii) the type of groove surface, and (iv) the volume of the negative scar made by the strike. The presence or absence of cortex is an indicator of the time invested in the production of the designs, since more time is needed to completely extract the cortex (Vergara 2009, 2013).

The edge of the fracture corresponds to the frontal face of the negative scars caused by the strikes. It is related to the gestures used in manufacturing, with elongated edges associated with movements semi-parallel to the block, and circular edges associated with movements perpendicular to the rock (Vergara 2009, 2013).

The type of surface of each scar and groove is associated with the movement made during petroglyph making: smooth surfaces result from abrasive techniques such as scratching or incision, while rough surfaces are produced by pounding (Vergara 2009, 2013). This is consistent with the research of Álvarez and Fiore (1995), who define the technique of incision as a unidirectional abrasive movement and scratching as a bidirectional abrasive movement. Finally, the volume of the negative scars corresponds to the type of instrument used; smaller volumes (0. 1mm^3 – 0.9 mm^3) are produced by smaller tools with sharp edges, while larger volumes (1 mm^3 – 3 mm^3) are made by instruments with rounded or wider edges. The negative scars were observed and sized through a 20× magnifying glass, measured with a digital caliper. Volume was calculated through mathematical formulas to quantify the volume of a cylinder (round negative scars) and a rectangle (non-round negative scars). These differences among the volume of negatives are related to the size of contact surface between the instrument and the rock. As replicative studies have shown, smaller contact surfaces are related to tools with sharper edges (Vergara 2009) (Table 1). This can be explained by the smaller contact surface of the former type of instrument in comparison to the latter.

Although our replicative studies have shown a clear relationship between these attributes, research must be conducted to explore how these variables react to different rocks. Nevertheless, our results could be approached as a first proposal about the marks that different movements and instruments left in petroglyphs grooves. In fact, as we point out, our results are coherent with previous studies and records of Alvarez and Fiore (1995) and Bednarik (1998, 2001).

Manufacturing petroglyphs involves a particular articulation among bodies, objects, spaces, and knowledge through a *chaine operatoire*. While the bodies execute the physical action that gives rise to the design, the objects are represented by instruments used for striking the rock upon which the intervention occurs. This is why Fiore (1996) segregates the operative chains of the instruments and the designs into two groups with different trajectories.

Along with the previous elements, space is also relevant. Given the immobile character of rock art, it is manufactured in the same place in which it is used or consumed. This is not only relevant in terms of the recognised dialectic between image and landscape (i.e. Bradley 1997, 2009), but also defines possible audiences and spatial syntaxes between phenomenological aspects and social practices. This idea engages with the conceptual difference among space and place (Tilley 1994), understanding the last one as a locality engaged with the history and social activities of a community. As many authors have pointed out (Tilley 1994, 2008; Bradley 1997, 2008; Jones 2007), distribution of images in space produce places where meanings, memory and social life are materialised. As rock art is engaged in particular ways with settlement, movements, audience and materials into in the landscape, its manufacture produces and reproduces particular strategies to create landscapes. Even more, the proper selection of rocks for engraving could be related to certain particularities of the place or the stone (Bradley 1997; Tilley 2008).

Based on our observations about the attributes described above, we shall now approach the material aspects that reveal technological choices used in the production of the petroglyphs in question.

Rock art in Valle del Encanto

The Valle del Encanto site is located in the lower basin of the Limarí River (30° lat. S), in north-central Chile in a landscape of narrow, green fluvial valleys surrounded by arid watershed territories (Fig. 1). The site in question extends along a small ravine watered by the Las Peñas stream and presents archaeological features over a distance of 1.5 km. There are many rocks within the ravine, recognising two sedimentary sequences (Sernageomin 2003). The first is dated to the Upper Miocene-Pliocene and it is characterised by alluvial and colluvial deposits. The second is dated to the Pleistocene-Holocene and it is characterised by alluvial deposits. Geologically, large rocks in Valle El Encanto are intrusive. Rock art was produced on granodiorite rocks, which have quartz (>10%) and feldspars. The site has been studied by several research teams since the early 20th century (i.e. Iribarren 1949; Ampuero and Rivera 1964; Klein 1972).

Seventy-two blocks with rock art have been identified, 14 of which contain paintings and 61 of which have petroglyphs; only three blocks have both. Additionally, there are at least 101 bedrock mortars with a total of over 400 grinding hollows. Bedrock mortars are distributed along the ravine but no spatial or visual relation to rock art has been discovered. In fact, no block contains both rock art and grinding hollows. Bedrock mortars were manufactured by hunter-gatherer communities and are recurrent in settlements of these

Figure 3. Petroglyhps under study: (a) cabeza tiara *of Limarí style; (b) 'non-figurative' design of El Encanto style.*

communities in the region (Ampuero and Rivera 1964, 1969; Schiappacasse and Niemeyer 1965–66). Several authors have proposed a function related to grinding plants (Ampuero and Rivera 1964, 1969; Schiappacasse and Niemeyer 1965–66, 1986) while we have recovered microfossils remains of maize (*Zea mays*) from one of them in Valle El Encanto.

Stratigraphic excavations of the site demonstrate the existence of domestic occupations and human burials by hunter-gatherer populations from the Late Archaic and Early Ceramic periods (Ampuero and Rivera 1964, 1969). These occupations are part of a residential mobility circuit used by these communities over a long period of time, from 2200 BCE to 1000 CE, according to 'absolute' dating. Although the excavations cover areas greater than 100 m^2, no occupations dating later than the Early Ceramic period have been identified. One Diaguita-Inca potsherd (1450–1540 CE) was recorded near a bedrock mortar during a recent excavation, but it is isolated evidence.

The richness of the archaeological context coupled with the frequency of petroglyphs and the complexity of some of their designs, particularly those referred to as *cabezas-tiaras* or heads with cephalic 'adornments', have made this the emblematic site for the chronological and cultural definition of rock art assemblages in the region, with its iconographic repertoire serving as the basis for regional and extra-regional comparisons (Schobinger 1985). Heads and 'headdresses' are recurrent in many rock art and iconographical contexts in the world (i.e. Schaafsma 2007; Soukopova 2011). In the Andes, heads have been interpreted as representation of high status people as well as a sign of fertility and power, while 'headdresses' have been related to status and social identity (Gallardo et al. 1993). For this reason, c*abezas-tiaras* in Valle El Encanto could be understood in the same vein. The combination of big heads and 'headdresses' could represent relevant persons in hunter-gatherer communities. The higher iconographic complexity of these motifs — when compared to other designs — supports the idea that they conveyed special meaning.

Though initially attributed to the Inca period (Iribarren 1949), the results of the excavations led Ampuero and Rivera (1964, 1969) to suggest that the rock art is mainly associated with the Early Ceramic period and, to a much lesser extent, the Late Archaic period. These proposals have been strongly questioned in the past few decades (Mostny and Niemeyer 1983, Castillo 1985), and more recent investigations suggest a 3500-year production sequence extending from the Late Archaic to late periods, based on the intrinsic characteristics of rock art (technique, designs, spatial distribution, superimpositions) (Troncoso et al. 2008).

Settlements of the Late Archaic period frequently have rock paintings in their proximity and some pieces of pigments have been recovered in stratigraphy. The petroglyphs, the main focus of our study, have been divided into two major groups: the first is called Limarí, and consists of petroglyphs of *cabezas-tiaras*, circles, circles with appendages, and headbands (Fig. 3a). One characteristic of this assemblage is their deep grooves. Mostny and Niemeyer (1983) have associated this group with the Early Ceramic period, based on the recurrent spatial relationship between Limarí engravings and settlement of hunter-gatherers in the region (Mostny and Niemeyer 1983), as well as on the resemblances of the motifs and symmetry patterns with the pottery of these communities.

The second group, referred to as El Encanto, is defined by petroglyphs with superficial grooves and predominantly schematic designs such as circles, lines, squares and anthropomorphous representations of bodies with two- or three-digit extremities (Fig. 3b). We associate these motifs with the Late Intermediate and late periods, represented by the Diaguita culture. This association is based on iconographical and symmetrical resemblances between rock art, Diaguita pottery and bone instruments. Moreover, elsewhere petroglyphs of El Encanto style are not related to hunter-gatherer settlements, except for the Valle El Encanto site. At the same time, motifs from both styles do not usually share

Sample	Limarí style total	Limarí style analysed	El Encanto style total	El Encanto style analysed
Blocks	11 (100 %)	10 (90.9 %)	47 (100 %)	28 (59.5 %)
Designs	30 (100 %)	15 (50 %)	173 (100 %)	50 (28.9 %)
Anthropomorphs	3 (100 %)	2 (66.6 %)	31 (100 %)	14 (45.1 %)
'Masks'	13 (100 %)	10 (76.9 %)	10 (100 %)	5 (50 %)
'Non-figurative'	14 (100 %)	3 (21.4 %)	131 (100 %)	31 (23.6 %)
Zoomorphs	0	0	1 (100 %)	0

Table 2. *Number of analysed designs.*

space on a same rock, and the few times this has been recorded (n=3), El Encanto motifs are superimposed over Limarí motifs.

These two groups of petroglyphs will be the focus of our discussion of the dynamics of technology and production, since these attributes have not been studied in depth for this type of rock art. Based on their technical characteristics and the contexts of their execution, we will discuss the social implications of these two ways of producing rock art, from the technical gestures to the audiences associated with them.

Material and method

In our study of the rock art of Valle del Encanto we have identified 30 designs attributable to the Limarí style and 173 to the El Encanto style. There are apparently non-figurative designs (14 Limarí, 131 El Encanto), masks or face representations (13 Limarí, 10 El Encanto), anthropomorphs (3 Limarí, 31 El Encanto) and zoomorphs (1 El Encanto). Our sample covers a total of 65 motifs, distributed over 38 engraved blocks, and includes examples of all different representations identified at the site, from *cabezas-tiaras* to non-figurative designs. It covers the best preserved petroglyphs in the site. The sample was arrived at through a stratified sampling that first considered the different styles and then the types of designs. Although variability is found on each category of motif, this sampling allows us to compare and evaluate the internal homogeneity or heterogeneity of the styles. Thus, our analysis considers a total of 15 petroglyphs of the Limarí style and 50 of the El Encanto style, and attempts to address the wider visual repertoire (Table 2). This translates into 50% of the Limarí group and 28.9% of the El Encanto group, given that there are fewer engraved blocks and designs of the former (Troncoso and Vergara 2013).

The analyses only considered the inherent attributes of the petroglyphs, the two most important variables being grooves and negative scars of the impacts.

For the grooves, we considered: (i) the nature of the groove, defined by the level of its continuity/discontinuity, differentiating between a continuous-discontinuous groove, a solid engraved area, or a combination of both; (ii) the presence/absence of the cortex of the rock in the groove, and (iii) the metrical attributes of the grooves and their homogeneity, considering the variation of the width, average depth and total length of the groove. The smoothness/roughness of the petroglyph was defined through the texture of the grooves and its regularity as in pottery and lithic analysis (Rice 2006; Andrefsky 2006). Specifically, we considered two aspects to define it, the micro-topography of the groove surface and the edge of fracture. Through visual inspection of the negative scar at 20× magnification, we defined 'smooth' as a homogeneous surface with no irregularities in the micro-topography. Also, edges of fractures are not so clear because abrasive techniques tend to erase them. Rough surfaces have an irregular micro-topography and edges of fracture are clearly visible.

The negative scars were observed through a 20× magnifying glass. In each of these units (negatives) three characteristics were considered: (i) the volume, (ii) the type of surface (rough and/or smooth) and (iii) the type of edge fracture. Results were later evaluated to identify the main tendencies.

Finally, in order to place rock art in the context of the site, a set of stratigraphic excavations were carried out close to the rock art blocks and in nearby areas, covering a total of 15 m^2, which can be added to the 100 m^2 excavated by previous researchers (Ampuero and Rivera 1964, 1969). The surrounding area was surveyed according to a grid and transect pattern (54 km^2). The results obtained from the analysis of these attributes were integrated and contextualised with the results of the on-site excavations.

Results: technological variability of the petroglyphs

As we initially stated, petroglyphs have been generally understood as a broad technological corpus within which differences are established based on attributes of manufacturing techniques such as pecks, scratches or incisions (Álvarez and Fiore 1995; Bednarik 1998, 2001) or, as in the present case, deep or superficial grooves. But there are other differences that allow us to build a broader understanding of their technological dynamics.

In this case, the results show that the two groups of petroglyphs vary in regard to the attributes analysed (Table 3), suggesting some important technological and productive differences between them.

In terms of the type of grooves, the Limarí group shows the almost exclusive use of continuous grooves (86.6%), whereas the El Encanto group displays both continuous and discontinuous grooves, and continuous and discontinuous areas (Table 3). Additionally, the

FORMAL PROPERTIES OF THE GROOVES						
TECHNOLOGICAL VARIABILITY			LIMARÍ GROUP		EL ENCANTO GROUP	
			No.	%	No.	%
GROOVE	TYPE OF GROOVE	Continuous groove	13	86.6	29	58
		Continuous-solid area groove	1	6.7	10	20
		Discontinuous groove	1	6.7	10	20
		Discontinuous-solid area groove	0	0	1	2
	WIDTH VARIATION	Maximum (cm)	1.7	-	3.2	-
		Minimum (cm)	0.2	-	0.5	-
		Average variation (cm)	0.9	-	1,4	-
	CORTEX	Presence	6	40	50	100
		Absence	9	60	0	0
	LENGTH	Total length	61.33	-	25.98	-
NEGATIVE SCARS	EDGE OF FRACTURE	Circular	10	66.7	50	100
		Lineal	5	33.3	0	0
	TYPE OF SURFACE	Rough	9	60	48	95.91
		Smooth	4	26.66	1	2
		Rough-smooth	2	13.3	1	2
	VOLUME	Average (mm^3)	0.62	-	1.21	-

Table 3. *Formal differences observed between Limarí and El Encanto groups.*

absence of cortex is predominant in the grooves of the Limarí petroglyphs, while in El Encanto petroglyphs the removal of the entire surface cortex (weathering zone) does not occur.

Other differences between the two groups are observed in their metric attributes. The Limarí group has more homogeneous grooves than the El Encanto group, which translates into closer values between the maximum and minimum width variation (Table 3 and Fig. 4). The total length of the grooves also diverges, with higher average values for Limarí (61.33 cm) than El Encanto (25.98 cm).

In relation to the negative scars from strikes, the groups differ in regard to all three aspects observed. The surfaces of the Limarí petroglyphs were judged smooth (26.66%), rough (60%) and smooth-rough (13.3%), as opposed to those from the El Encanto group, where there is a clear concentration of rough surfaces (95.91%) (Table 3). Regarding the volume of the scars, the values of the Limarí group are significantly lower than those of El Encanto. The depth of the grooves also differs, with higher values associated with the Limarí group (Figs 4 and 5)

This set of differences suggests that there were a variety of technological options associated with the techniques, gestures and instruments used in the act of striking the rock (Tables 3 and 4).

In terms of technique, El Encanto is characterised by the use of direct percussion, as demonstrated by the presence of almost exclusively rough surfaces (Vergara 2009). In contrast, Limarí displays a combination of direct percussion and abrading, as evidenced by the coexistence of the three types of surfaces: (i) rough, (ii) smooth-rough and (iii) smooth (Table 3). As our replicative studies show (Vergara 2009, 2013), while rough surfaces are related to direct pecking, smooth grooves are the result of reiterative abrasive action. There is no record of indirect percussion that is coherent with the scant records of this type of technique at the global level, as suggested by Bednarik (1998, 2001).

These data are consistent with the depths of the grooves. The deepest grooves of the Limarí group resulted from a continuous pounding and abrading action, whereas the shallowest grooves of the El Encanto group resulted from percussion, an activity of short duration. Although the depth of Limarí grooves could be achieved only by pecking, the

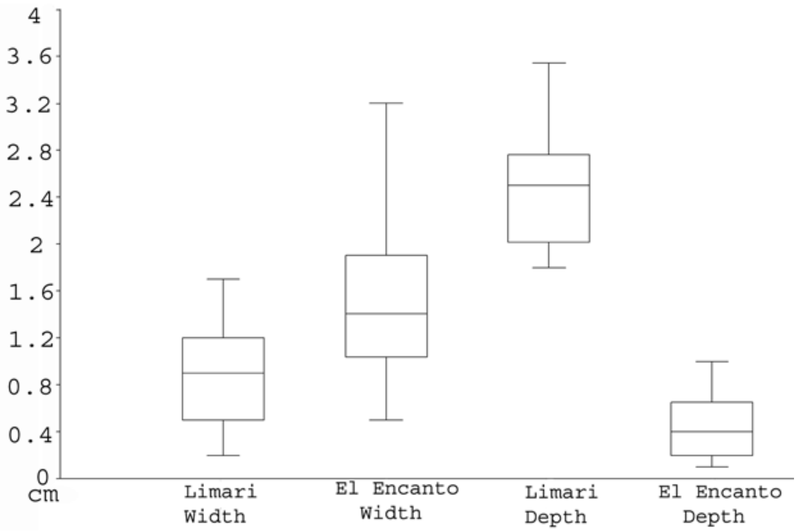

Figure 4. *Box-plot showing depth of groove and width variation in Limari and El Encanto petroglyphs.*

surfaces of the groove support the inference of both pecking and scratching action. This also explains the absence of cortex in the deeply engraved grooves, since the continuous process of pounding and abrading would completely eliminate the rock surface layer.

Considering that the designs of the Limarí group have longer and deeper grooves, we can argue that producing them required a greater investment of labour than the El Encanto petroglyphs. As both types of petroglyphs have the same kind of rock support, the energy investment required to remove the rock surface was greater in Limarí than in El Encanto, as different replication studies clearly show (Bednarik 1998, 2001; Whittaker et al. 2000; Vergara 2009, 2013). The high variability in the depth of the deep-groove petroglyphs is consistent with a continuous process of pounding and abrading and not with a single quick action.

Figure 5. *A view of depth of groove in a Limarí and El Encanto petroglyph.*

In regard to the instruments used to produce the rock art, the volume of the negative scars and the variation in groove width are both indicative variables (Vergara 2009). What they indicate is that rounded stones were used for the El Encanto style, as the size of the scar volumes (greater than 1 mm^3) suggest. In contrast, the Limarí style is more heterogeneous, presenting volumes both greater and lesser than 1 mm^3. This variability can be found in a single design or by comparing two separate petroglyphs. The presence of smaller volumes indicates that the contact surface of the instruments was specially prepared, or that angular stones were chosen to produce the petroglyphs. At the same time, larger volumes indicate the use of rounded stones, a conclusion supported by the smooth surfaces obtained. This interpretation is based in our replicative studies as well as the fact that a smaller contact surface between a stone tool and a rock produce smaller negative scar in petroglyphs. We can therefore say that both types of instruments were used — angular stones for direct pounding, and rounded stones for abrading. Such stones can be found on the ground at the site, and some additional rounded stones have been recovered in excavations (>10), which have some marks of impact (basically a pecking in its distal border). These instruments are informal artefacts (Andrefsky 2006), rudimentary pieces that required little energy to create. They were manufactured from raw andesite, which could be gathered in Valle El Encanto or nearby areas. Their manufacture consisted in some strokes to improve the border of the instruments and no special treatment or traits were identified. They coincide with instruments identified in other places (see also Pilles 1975; Álvarez and Fiore 1995; Bednarik 1998, 2001; Whittaker et al. 2000; Álvarez et al. 2001).

One of the variables indicative of gesture is the edge of the fracture on the negative scars, and here again the two styles differ, with the El Encanto group showing exclusively circular-type edges, indicating that the techniques and instruments were used in a direction perpendicular to the block, and the Limarí group displaying two types of edges — linear ones that are related to movements over 135° in relation to the block surface, and rounded edges. The latter is consistent with abrasion and direct pounding, since these entail a bidirectional movement of the artefact followed by a strike of the block that directly impacted the surface (Álvarez and Fiore 1995).

In addition to these differences in techniques, instruments and gestures, the attributes described above suggest that there is also a difference in the ways the designs were constructed. The presence of different types of marks in the grooves of the El Encanto petroglyphs (continuous/discontinuous, solid areas/lines) demonstrates the use of different visual solutions in the creation of images. While some petroglyphs are clearly delineated on the rock, others are irregular. The latter lack clear outlines and sometimes the motif has just been insinuated on the rock (e.g. a couple of strikes which follow a circular path, but which do not mark a circle). But such variety is not seen in the Limarí group, which is completely homogeneous in this respect. This also means that representations of the El Encanto type vary not only in their degree of visibility, but also in their differential forms of perception, since in the case of the discontinuous grooves the designs are not fully outlined.

	Limarí group	**El Encanto group**
Number of petroglyph blocks	11	49
Techniques	Direct pounding and abrading	Direct pounding
Type of instruments	Angular and rounded stones	Rounded stones
Gestures	Perpendicular-bidirectional stroke	Perpendicular stroke

Table 4. *Technological options in the production of both groups.*

Discussion: rock art, technique, technology and history

The results obtained from our analysis of the petroglyphs show that, beyond the fact that they are all petroglyphs, there are important differences in the technical attributes of their designs. These suggest different dynamics of production that are recognisable in the techniques applied and in the instruments and gestures used. Although some characteristics of both instruments and techniques are reiterated in different contexts around the globe (e.g. the kind of the instruments used; Bednarik 1998, 2001; Whittaker et al. 2000), it is the articulation among the objects, gestures and actions used to manufacture petroglyphs that allows us to begin to see divergences between the two sets of petroglyphs, divergences that expand even more when we incorporate the contexts in which they were executed.

The production of the Limarí group of petroglyphs would have involved the selection of sharp instruments made of hard raw materials that could directly pound the rock surface. These were most likely gathered or manufactured from raw andesite or basalt, which can be found in Valle del Encanto. These types of instruments have been identified at other rock art sites in the region (Méndez 2008) and possess the attributes that Bednarik (1998, 2001) has defined for these kinds of pieces. Round stones that could have been gathered near streams or rivers could also have been used for making abrasions.

At the same time, the production of these petroglyphs would have entailed a series of gestures related to the techniques used. On one hand the block would have been pounded in a perpendicular manner, and on the other bidirectional abrasion would have been used to shape the grooves of the desired figure.

The depth and type of groove surface not only reaffirms the combination of abrasion and direct percussion techniques proposed, but also points to other fundamental attributes of rock art manufacture — the frequency and timeframe of their production. In effect, variation in the depth of these grooves, added to the fact that they all have similar surfaces (smooth-rough and rough), indicates that the same techniques and type of instruments were used over a long period of time, on a very small number of designs and blocks.

This situation suggests that the practice of making petroglyphs did not emphasise the production of many motifs in the landscape. It was focused in marking some rocks, on making deep images on them, acting once and again over the same image. Considering the labour involved in the production of each motif, depth differences and the sequences of pecking and smoothing in the grooves, we think that motifs were re-marked following the same technological norms. Instead of engraving new motifs, hunter-gatherers focused on the pre-existing ones, deepening them.

Regardless of the above, the length and depth of these figures and the absence of rock cortex inside the grooves demonstrate that more labour was invested to produce these Limarí petroglyphs than those from the El Encanto group. This is consistent with the lower frequency of these designs on blocks at the site, as it reaffirms the idea that most of the labour went into deepening a primary group of petroglyphs instead of into creating new designs around the space. In fact, Limarí rock art is less represented in regional surveys than El Encanto petroglyphs (Troncoso and Vergara 2013; Troncoso et al. 2014), reaffirming the pattern that we have seen in the site.

This production dynamic cannot be considered separately from another relevant aspect linked to the manufacturing context: the spatial association between rock art and hunter-gatherer settlements. In fact, Valle El Encanto, as well as other archaeological sites of hunter-gatherers with marked rocks, is characterised by stratigraphic deposits which include several categories of lithic instruments of different raw materials of unfinished *chaines opératoires* (projectile points, scrapers, knives, grinding stones, flints, flakes); a few potshards related to small and medium-size containers; pieces of animals bone (basically guanaco, *Lama glama* sp.), which were captured and butchered away from the site; marine seashells; hearths and sometimes a couple of human burials (Ampuero and Rivera 1964, 1969; Schiappacasse and Niemeyer 1965–66, 1986). Site placement is related to secondary watercourses and proximity to natural routes that lead to the Pacific coast. Contextual and spatial information has been used to propose a residential mobility for these groups between the coast and inland (Ampuero and Rivera 1964; Schiappacasse and Niemeyer

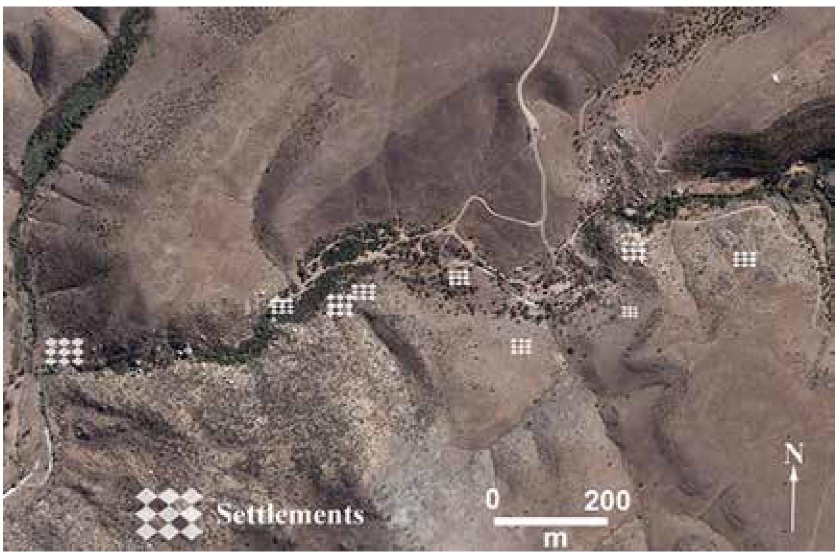

Figure 6. Settlements of hunter-gatherers in Valle El Encanto.

1965–66, 1986). Rock art production was engaged with all of these materialities and practices, which were done recurrently in the same places as part of a residential mobility. Unfortunately, no studies about seasonality of movement have been done in the area. The chain of production of these petroglyphs was integrated into those circuits as well as it was part of a phenomenological context in which the manufacture of rock art was linked with other everyday activities (Fig. 6).

The temporary reuse of this settlement as part of a residential mobility system also could imply that the same rock art designs were reactivated and constantly maintained. Thus the Limarí group is defined by an operative chain that brings together all steps needed to manufacture rock art in the same space, matching the artefacts' operational ability with the representations (Fiore 2007). Within this process, a strategy for preserving the images would be a key factor in the dynamics. Notably, an entirely different rock art production dynamic is associated with the El Encanto group. Here, the operative chain begins in a similar way to the Limarí group, involving the selection of hard instruments manufactured from andesite or basalt that could be picked up around the site. These instruments would have been used solely to directly pound the block, with the same gesture used to produce all of the petroglyphs, i.e. the perpendicular pounding of the rock surface.

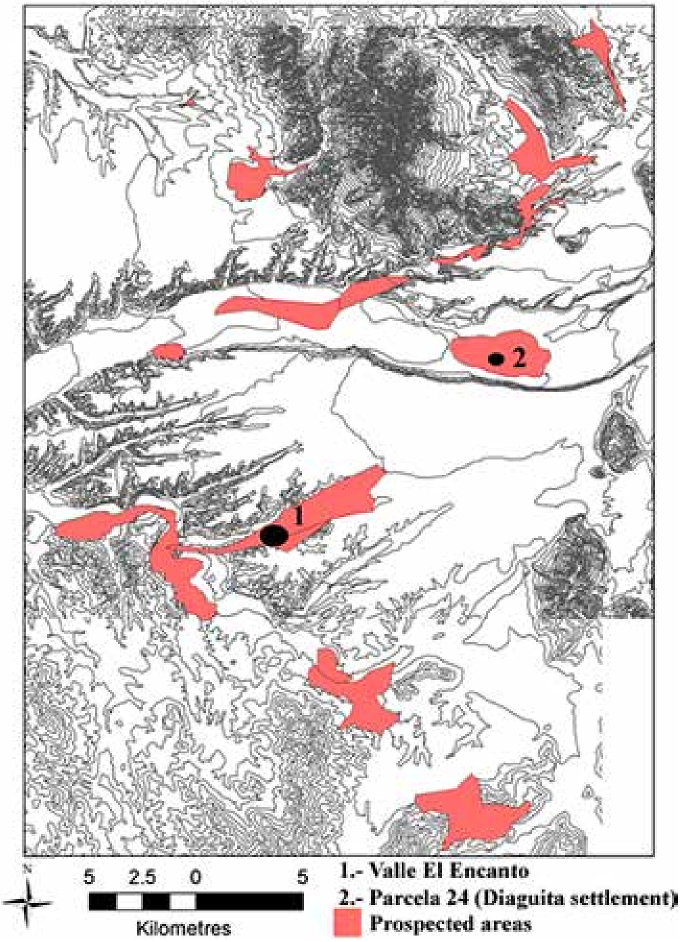

Figure 7. *Prospected areas (red colour) in Limarí's valley and localisation of Valle El Encanto and Diaguita settlements.*

The use of direct percussion is associated with variations in the form of marks, which can be continuous, discontinuous or covering a solid area. This variation, coupled with the shallow depth of the grooves and the short length of the designs, indicates that the El Encanto creators were more interested in creating new designs in different spaces within the site than in deepening the same figures. In other words, while the labour invested in the Limarí petroglyphs is reflected in deep, large-scale petroglyphs, that invested in the El Encanto petroglyphs is reflected in a greater number of representations and a wider network of spatial interventions (Fig. 1).

In the same way, the manufacturing techniques used to produce these designs are more heterogeneous, involving different kinds of marks and grooves with and without cortex. There is also a greater profusion and diversity of designs, and this variability is consistent with more abundant petroglyphs over a larger space, rather than with maintaining the same designs. The diversity of attributes shows that the designs are very well elaborated, with a groove depth variation of less than 10 mm, suggesting very effective control of the strokes. But there are also designs with very irregular grooves, with widths that vary more than 10 mm. This shows not only that different norms governed the production of designs, but that those who produced them may have had different levels of expertise, given the difference in stroke control that this variability may indicate.

As opposed to the previous group, the production dynamics associated with this group of petroglyphs indicate that their manufacture was not integrated with the community's everyday activities, as the excavations carried out in different parts of the valley did not yield any stratigraphic deposits consistent with related residential activities (Ampuero and Rivera 1964, 1969; Troncoso 2012). Grinding instruments excavated in association with the bedrock mortars on site have been attributed to hunter-gatherer communities (Troncoso 2012), but a survey of spaces around the valley did not yield occupations associated with Diaguita populations (Ampuero and Rivera 1964, 1969; Troncoso 2012). Surveys of the areas surrounding the site showed no Diaguta settlements, with the closest sites being 9 km away (Fig. 7). Taken together, the data demonstrate that the production of these rock art petroglyphs was spatially segregated from day-to-day activities, meaning that the individuals who created them had to come from their settlements to produce it. This spatial segregation may partially explain the dramatic increase in the number of engraved blocks, for while in previous periods different parts of the site were occupied by residents, thus concentrating the petroglyphs in a few areas, the absence of residential occupation in the ravine

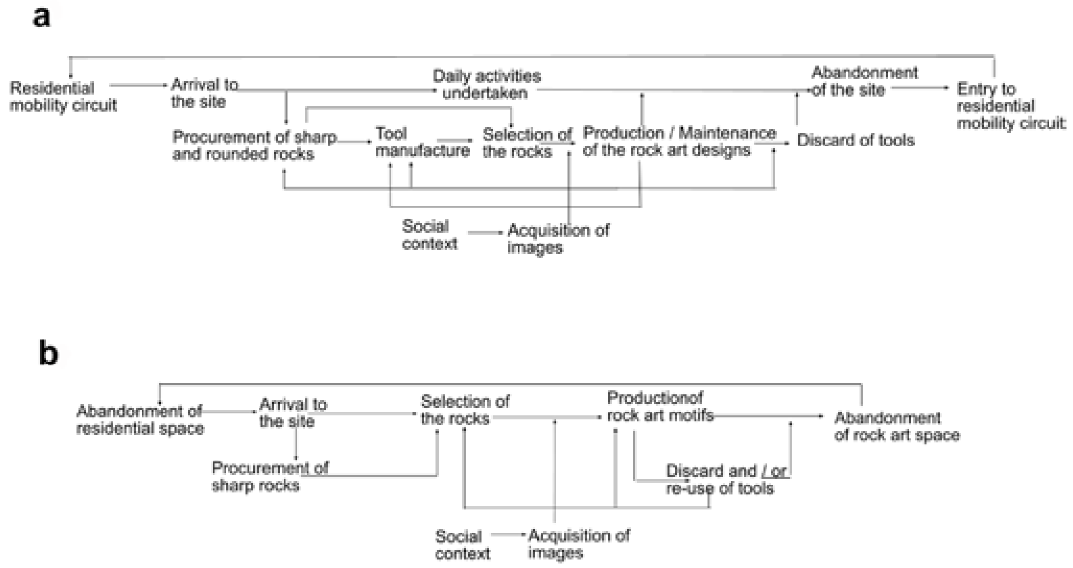

Figure 8. *Diagrams that represent the production of both rock art styles: (a) Limarí style, (b) El Encanto style.*

during this later period enabled the spatial scale of the rock art to be expanded and the entire site used for this purpose. In this way, the manufacturing of rock art and the flow of information from the petroglyphs are spatialised, constituted into spaces with a more public or communal nature, since they are not restricted only to residential areas (Fig. 8).

The technology of petroglyphs made by the Diaguita culture broke with the previous *chaine operatoire*. Spatial segregation of rock art from settlements implies a new strategy to produce cultural landscapes and other kinds of phenomenology. The reiteration of this pattern in other Diaguita sites shows the relevance of this spatial transformation in the sequence of rock art production by agrarian communities.

Conclusions

Although less understood than the spatial and visual dimensions, the technological dimension of rock art provides a useful way to delve into not only the technical and manufacturing procedures of rock art (Bard and Busby 1974; Pilles 1975; Bednarik 1998, 2001; Whitakker et al. 2000), but also the social and cultural aspects of the past associated with these procedures (Fiore 1996, 2007). And it is these latter procedures that lend a historical and cultural particularity to the making of rock art.

Our case study has shown how the technical procedures used at this site share a series of similarities with other spaces registered, indicating that the technical solutions developed here were similar to those recorded for other parts of the globe and, without a doubt, are related to the nature of the work performed and the raw materials deployed to perform it. The absence of indirect percussion, the use of local raw materials and the use of rudimentary instruments with sharp edges are variables that are reiterated across many regions (Bednarik 1998, 2001) and point to such parallel techniques.

The difficulty of identifying these instruments, owing to their rudimentary nature and the weathering they have been exposed to after being left in the open air for such a long time (Bednarik 1998, 2001) makes the study of petroglyph grooves even more important, as another way of understanding these technical dimensions. Nevertheless, as Bednarik (1998, 2008) suggests, in the case of instruments there is a need for new, more extensive replication studies that employ different types of variables (e.g. raw materials) in different environments in order to adjust indicators to each region and enable the identification of similarities and differences around the globe.

Now, these technical procedures are not employed homogeneously or independent of their time, but are enmeshed in a way that lends meaning to the materialities within a given social context; it is their integration within a social milieu that makes them technology, and 'above all, means and mediums for the production and reproduction of social life' (Schalngen 2005: 20).

Thus, we have identified the essential homogeneity of the petroglyphs analysed here but beyond this, they provide evidence that there are different ways to exert technical knowledge and articulate technology. These variations are found at the instrumental level, as well as in the manufacturing techniques and gestures, which express different solutions for creating petroglyphs that are associated with different approaches to the production of rock art.

The diverse production dynamics identified for these groups, as expressed in different productive sequences, refer not only to technical procedures, but also to the phenomenological contexts in which their production was situated. These material and contextual divergences are consistent with the meanings and functions of rock art in pre-Hispanic social life (Fiore 2007). In effect, the concentration of rock art made by hunter-gatherer populations in their settlements and the placement of petroglyphs in public spaces by agrarian societies suggest that there were different socio-spatial orientations for this materiality in local pre-History. Thus, the flow of information and the associated meaning of this materiality are dependent upon not only different spatial contexts, but also in distinct technical processes that emerged from distinct operative chains.

It is relevant that this distinctiveness is related to the different technological practices of nomadic and sedentary groups. As both communities inhabited the same space, the limitations that the material imposed on their production of petroglyphs were the same for both groups. The greater homogeneity displayed by the petroglyphs of the first group — in regard to metrical attributes and the themes depicted — is associated with low-scale societies such as those of the Early Ceramic period, in which the small size of social units limits the potential variation of productive norms. The productive dynamic of re-engraving is associated with mobility circuits in which these groups reused sites over and over again, orienting the productive process towards intense manufacturing of petroglyphs in their settlements with a focus on deepening existing petroglyph designs rather than creating new ones to expand their coverage in the region.

In contrast, the greater heterogeneity of the later petroglyphs is consistent with a society like the Diaguita, which existed on a much greater scale than the previous group. It was organised into supra-familiar social units with limited face-to-face interaction as a consequence of their dispersed settlement pattern, which would have provided an opportunity for greater variability in productive norms. Unlike the previous case, re-use of petroglyph designs is no longer governed the productive dynamic; instead, this was substituted by extensive petroglyph manufacturing that not only covered different spaces in Valle El Encanto, but was reproduced at the regional level as well (Troncoso 2012). This not only led to a more varied array of petroglyph producers but also enabled the petroglyphs to reach audiences beyond the residential unit, given that at the site studied, and in the region, there are no residential occupations associated with the Diaguita culture. The opposite situation occurred with the hunter-gatherer groups, which had an asocial system that focused on the flow of information towards small social groups in a domestic context that ultimately demarcated a residential space (Troncoso et al. 2014). Meanwhile, the system of agrarian communities was other-focused, centred on circulating information within large social groups that required shared spaces in which to share the ideas that defined the community.

Thus, the two styles have not just differences in motifs and techniques; they show different *chaine operatoires* related to particular ways of life, landscape production and size of communities and audiences.

This break between rock art styles was probably related to different understandings about the place and rock art for both communities. In fact, probably the transition from Diaguita to Valle El Encanto communities to make petroglyphs was related to the importance of this place and the existence of ancient rock art and grinding hollows. Nevertheless, the latter's approach to this site and rock art differs from the hunter-gatherers.

Technological transformations from one style to the other imply a relevant social change that we have not approached yet. It was not just an iconographical and technical change. It was engaged with a modification of settlement patterns, movements, audiences and landscape construction. In fact, we do not know the temporal rates of the change. The low resolution of chronology in rock art studies does not allow us to discuss the transition between both styles and how technological transformations occurred. While Limarí style is intensive, focused on a reiterative deepening of the grooves but with a low scale of intervention in the site, El Encanto style is characterised by a wide use of many rocks along the valley and production of many different kinds of motifs. This engagement among technology, landscape and rocks is replicated on a greater scale, with a low quantity of Limarí petroglyphs engraved while the El Encanto style is widely recurrent in the region (Mostny and Niemeyer 1983; Troncoso andVergara 2013).

Nevertheless, differences between *chaines operatories* of rock art in hunter-gatherers and agrarian societies show us that a different engagement with landscape and movement was developed. In fact, as Ingold points out (1987), systems of spatial communication in hunter-gatherers are related to mark the settlements and paths, while in agrarian societies it focused on demarcating wide territories they inhabited. Rock art in Valle El Encanto is coherent with this and with the movement strategies of each society.

Whatever it was, the three basic dimensions of rock art — material, spatial and visual — together form an articulated whole that lends meaning to this materiality in the social sphere. Therefore its technical attributes not only provide us with details about its manufacture, but also shine light upon the procedures and relevant technological content of social life in the past. As Ihde (1979) describes it, each technical choice and sequence of procedures has its own associated phenomenology and social universe.

Thus, the technological aspect of rock art can be observed not only as technical solutions geared towards achieving a certain materiality; it also allows us to understand the narrative component behind these solutions. In this sense, technology acts as a discursive element that articulates gestures, techniques and tools for specific audiences, phenomenologies and spaces of action. In other words, technology provides a syntactical connection between the material and cultural spheres, and therefore studying it can improve our understanding of production dynamics and the meaning of rock art.

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