LITHIC RAW MATERIALS AND MODES OF EXPLOITATION IN QUARRIES AND WORKSHOPS FROM THE CENTER OF THE PAMPA GRASSLANDS OF ARGENTINA

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Quarry workshops have an important economic, social, cultural, and symbolic role for past hunter-gatherer societies and the northwest Tandilia System would have represented a place of great cultural significance because human groups could have exploited a huge diversity of rocks and minerals. The main objectives in this paper are to analyze different exploitation, production, and use strategies applied on chert and silicified dolomite quarry workshops, and to interpret diverse ways of transport and circulation of these lithic raw materials from procurement areas to other sites in the center of the Pampa grasslands during the Late Holocene. The studies done suggest several modes in raw materials selection in quarries, reduction strategies, tool manufacture, and rock circulation in the landscape. It is proposed that both raw materials could have been transported from workshops to other sites in the form of nodules, different kinds of partially and/or totally decorticated cores, large flakes, and possibly tools. With the reduction of residential mobility in hunter-gatherer groups during the Late Holocene, the most exploited rocks in the center of the Pampa grasslands were those located nearest the sites, such as chert from the Sierras Bayas hills. Two procurement strategies (embedded and special trips by using logistical mobility) could have been applied on chert and silicified dolomite acquisition. On the other hand, human groups occupying territories far from quarries could have obtained them through social exchange and interaction networks.

KEYWORDS: *Argentina, Stone tool technology, Quarry workshops, Chert, Procurement strategy*

Rock identification and characterization in procurement areas, as well as techno-morphological studies of lithic materials associated with extraction activities and initial reduction, provide important information in order to interpret the technological organization of past hunter-gatherer societies. Also, these kinds of investigations offer information about what access to resources existed, what their acquisition costs were, which social and symbolic factors were involved, and how rocks were transported from procurement sources to other sites within the settlement system (Affolter 2002; Andrefsky 1994; Beck and Jones 1990; Beck et al. 2002; Binford 1979; Nelson 1991; Taçon 2004; Torrence 1986).

Despite methodological difficulties in studying quarries and workshops sites (e.g., palimpsests and large amounts of undatable and redundant material), several authors have shown that these types of contexts had important economic, social, cultural, and symbolic roles (e.g., powerful social values, exchange networks, and maintenance of social and political alliances) for human groups (Bamforth 1990; Ericson 1984; Gould and Saggers 1985; Nelson 1991; Ross et al. 2003; Taçon 2004; Topping 2011; Torrence 1986). For the past two decades, research on rock availability in the Pampa grasslands of Argentina has been plentiful and has been oriented toward macro- and microscopic characterization of lithic raw materials, the way rocks appear in sources (i.e., availability, distribution, abundance, variability, and knapping quality), and how rocks have been exploited in different outcrops (Barros and Messineo 2006; Bayón et al. 1999; Bonomo 2005; Catella et al. 2013; Colombo 2011; Flegenheimer et al. 1996; Messineo et al. 2004; Oliva et al. 2006).

The lithic resources are highly localized and heterogeneously distributed across the Pampa grasslands (Figure 1). Therefore, researchers have argued that this characteristic influences the sort of strategies that hunter-gatherers used to acquire and exploit these resources, as well as the way lithic raw materials circulated in the landscape (Barros and Messineo 2006; Bayón et al.

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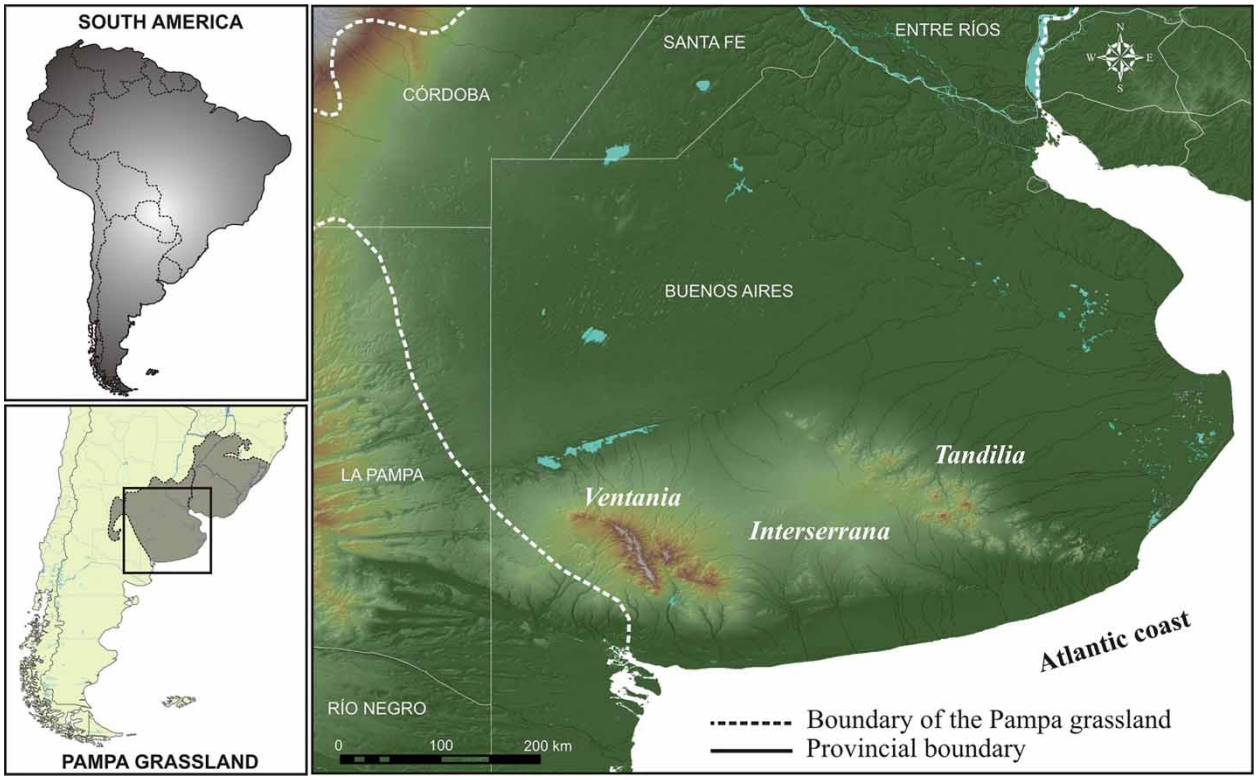

FIGURE 1. Location map of the Pampa grasslands of Argentina.

2006; Bonomo 2005; González 2005; Martínez and Mackie 2003–2004). Some authors have proposed that the acquisition of lithic raw materials would have been done by specific trips and not as a secondary activity (Colombo 2011; Flegenheimer et al. 1996; Martínez and Mackie 2003–2004). On the contrary, Franco (1994) has suggested that, although special trips in search of raw material would increase too much the procurement costs, we can think that in an area where lithic raw materials are scarce, strategies used by human groups would be in the first place conditioned by the need for obtaining the resources that were scarce.

Bayón et al. (2006) state that stones were obtained in different ways, and propose a classification depending on the distance that raw materials were transported. The authors suggest that the regionally important and predominant rock in archaeological contexts was the fine-grained orthoquartzite of the Sierras Bayas Group, for which extensive exploitation areas have been recognized in the central-south sector of Tandilia Hill System (Colombo 2011; Flegenheimer et al. 1996). They also recognize chert, rock whose procurement has an areal importance, predominating near the sources but with a secondary significance in contexts of other areas (Bayón et al. 2006). Lozano (1991) proposes that chert is nonlocal in most of the sites in the Pampa grasslands, that it occupied a secondary place in lithic raw material preferences, and that it was curated, which led to a considerable time and energy investment in its acquisition, transport, and use.

In the center of the Pampa grasslands, and in contrast to what has been observed in other areas of the region (Bayón et al. 2006; Martínez 2006), during the Late Holocene, a predominance of the Cerro Largo Formation chert is found in some archaeological sites located less than 45 km from northwest area of the Tandilia Hills System, such as Laguna La Barrancosa 2, Arroyo Tapalqué 1, Blanca Chica, Calera, and the upper levels of El Puente sites (Messineo 2011). In these sites, the Cerro Largo Formation chert is represented by large size debitage, flakes with high cortex presence, several formal and informal tool types (e.g., side scrapers, end-scrapers, notches, projectile points, retouched flakes, and utilized flakes), and cores with different shapes that provide evidence for different stages of the *chaîne opératoire*. Technologically, an expedient strategy is observed in the making of chert tools, in its lack of standardization

(except small triangular projectile points and some end-scrapers), and in the wide variability in core reduction (Barros et al. 2014; Colantonio 2013; Messineo 2011).

Taking these studies into account, the main objectives of this work were: (1) to characterize lithic raw materials that can be found in the northwestern sector of the Tandilia Hills System (center of the Pampa grasslands, Buenos Aires province, Argentina), especially those that have been used for knapping; (2) to analyze and discuss different exploitation, production, and use strategies applied by human groups to raw materials from chert and silicified dolomite quarry workshops; and (3) to interpret different ways of transport of these lithic raw materials from procurement areas to other sites in the center of the Pampa grasslands. Finally, we discussed why hunter-gatherers groups carried out greater exploitation of local lithic resources during the Late Holocene (last 3500 ^{14}C years BP), contrasting this specific procurement pattern with changes in human's mobility strategy and foraging systems.

The Pampa Grassland and Its Lithic Resources

In South America, the subhumid temperate grassland, between 28° and 38°S, is an extensive plain covering the east-central of Argentina (Pampas), Uruguay, and southern Brazil (Campos) (Soriano 1992). The Pampa grassland of Argentina is limited by the Atlantic Ocean to the east and southeast, and is surrounded by xerophytic woodland (Espinal and Monte phytogeographic provinces) that extends to the west, the north, and the northeast. The Pampa grassland is interrupted by Tandilia and Ventania mountain ranges and in its southern portion is connected with the coastal plain (Figure 1).

In the mid-1980s, archaeological research in the Pampa grasslands included the analysis within the organization of technology theoretical framework (*sensu* Ericson 1984), thus becoming the foundation for the analysis of strategies applied by human groups in the acquisition of lithic and mineral resources (Bayón et al. 1999). The study of rock outcrops was carried out to locate potential procurement sources, quarry workshops, workshops, and to know the regional structure of lithic resources (for a synthesis of the main results, see Barros and Messineo 2006; Bayón et al. 1999; Oliva et al. 2006).

In the southern sector of the Pampa grasslands, there are four main areas for the acquisition of lithic raw materials that have been used for tool manufacture (Figure 2). Extensive primary outcrops are located in the Tandilia and Ventania Range Systems, with smaller isolated outcrops in the Interserrana area. There are also secondary deposits available in some fluvial valleys and on the Atlantic coast (Bayón and Flegenheimer 2004; Bonomo 2005; Catella et al. 2013; Colombo 2011; Flegenheimer et al. 1996; Messineo 2011). Figure 2(a) shows the location of the main outcrops and workshops of different lithic raw materials that were used by hunter-gatherer groups in the past (e.g., fine-grained orthoquartzite of the Sierras Bayas Group, chert, silicified dolomite, coarse-grained orthoquartzite of the Balcarce Formation, metaquartzite, quartz, rhyolite, basalt, silicified tuff, and granite).

The Lithic Resources in the Northwestern Sector of Tandilia

The western foothills of the Tandilia Hills System are characterized by tier-reduced area and elevation, with low tabular hills, and gentle discontinuous small hills (Figure 2(b) and (c); Poiré and Spalletti 2005). Since 2000, several archaeological surveys have been carried out in the Sierras Bayas and Sierra Chica hills in order to determine potential lithic sources, quarry workshops, and workshops of raw materials used both for chipped and grinding stone tools (Barros 2009; Barros and Messineo 2006; Messineo 2008, 2011; Messineo et al. 2004). The main aim was to characterize lithic raw materials that can be used by hunter-gatherer in the center of the Pampa grasslands. In the following paragraphs, we describe the potential procurement sources for every knapping lithic raw material identified in the northwest Tandilia.

Orthoquartzite has been recognized in three geological formations: Villa Mónica, Cerro Largo, and Balcarce (Figure 2(c)). During surveys in the Sierras Bayas, natural outcrops of the inferior level of orthoquartzite were not recorded. In the case of orthoquartzite from the superior level, outcrops appear in the crest and the south slope of the three Sierras Bayas orographic cores. For this lithic raw material, a quarry workshop with a reduced exposed surface was identified at the Aguirre hill corresponding to a brown type (Messineo 2011). We can characterize orthoquartzite of the Sierras Bayas hills as a rock with a regular to poor knapping quality; however, an

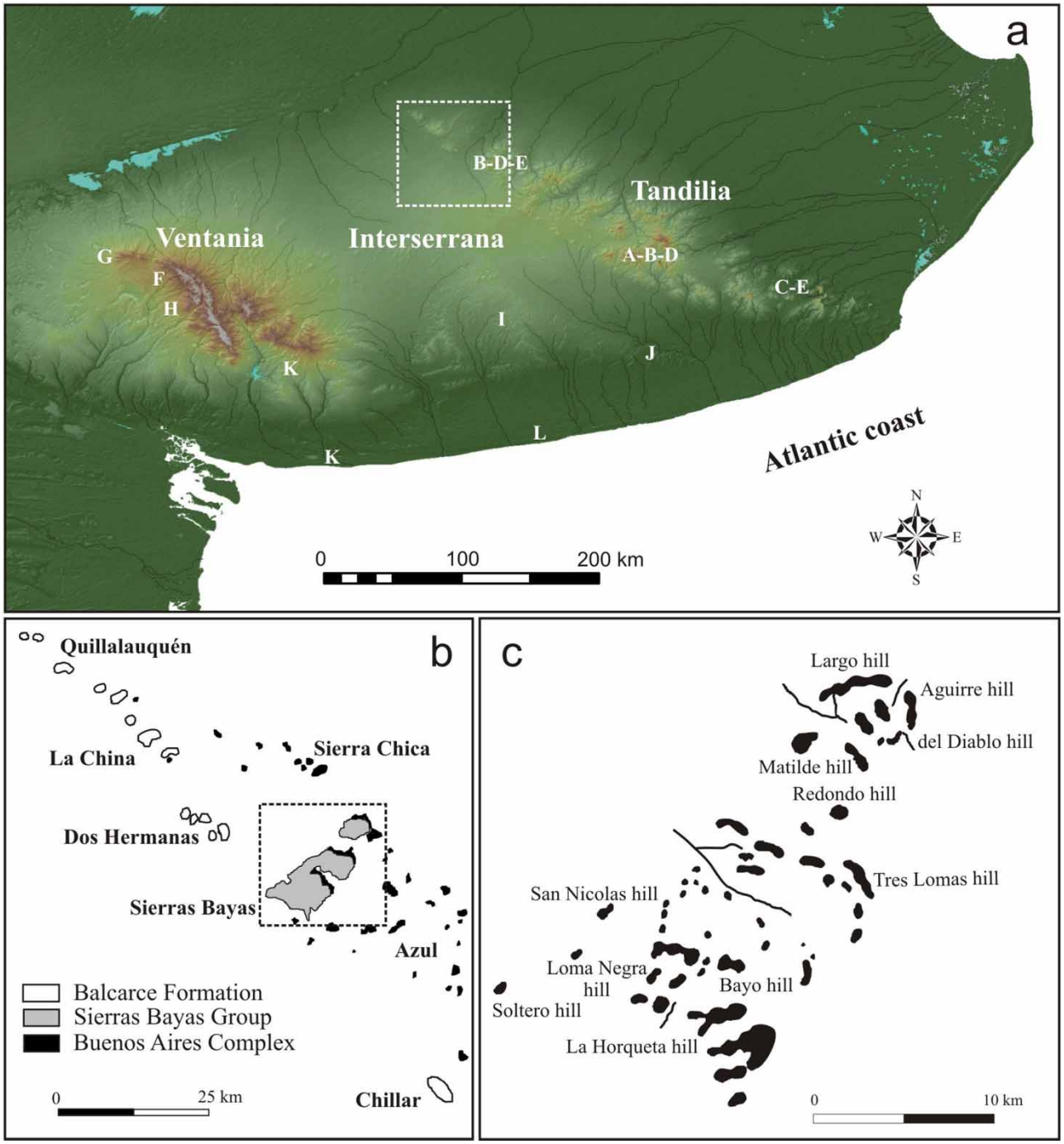

FIGURE 2. Location map of the southern Pampa grassland and main rock outcrops (a); map of Northwest Tandilia Hill System (b); Sierras Bayas hills (c); (A) orthoquartzite of the Sierras Bayas Group; (B) chert; (C) orthoquartzite of the Balcarce Formation; (D) silicified dolomite; (E) quartz; (F) rhyolite; (G) metaquartzite of La Mascota Formation; (H) granite and orthoquartzite; (I) tuff; (J) quartzite sandstones and metaquartzite; (K) metaquartzite and quartz; and (L) costal cobbles.

orthoquartzite outcrop with a good knapping quality was also detected in the area. This outcrop can be considered as a potential lithic source.

Although no evidence of exploitation of white orthoquartzite of the Sierras Bayas Group and the Balcarce Formation was found in the northwestern sector of Tandilia, in some archaeological sites from the center of the Pampa grasslands, there are debris with cortex remains, large cores, and tools of different qualities (hammerstones, mortars, and use-modified artifacts) that could indicate its possible local exploitation (Messineo 2011). However, we cannot yet discount that this

resource comes from other areas of Tandilia or Ventania and we need further research.

The carbonic sequence is the broadest of the series represented by dolomite of the Villa Mónica Formation (Sierras Bayas Group; Gómez Peral 2008). This nonsilicified rock is brown and it protrudes from the Sierras Bayas slopes (Figure 2(b) and (c)). Silicified dolomite is found in very restricted areas of the Tres Lomas, Aguirre y Largo hills (Barros 2009; Barros and Messineo 2006; Gómez Peral 2008; Messineo 2011). In Tres Lomas hill, a 2 m-thick outcrop corresponding to the silicified dolomite level with clear evidence of exploitation was detected. This stratigraphic level appears as a silicified lens (breach) composed of blocks and nodules of different sizes.

Chert has been recognized in three stratigraphic levels within the Precambrian/Paleozoic sedimentary sequence of Sierras Bayas (Figure 2(c)). The first and third chert levels (Villa Mónica and Loma Negra Formations) do not outcrop naturally in any hill, since they were identified in a contemporary quarry. The second chert level of the Cerro Negro Formation outcrops in all the hills (e.g., Aguirre, Largo, and Tres Lomas) and it is associated with archaeological quarries and workshops that have high densities of knapped materials (Barros and Messineo 2006; Lozano 1991; Messineo 2008, 2011). However, the distribution of this level on the slopes is not continuous and homogeneous but rather the identified breaches stick out in isolation in several areas in the hills due to its resistance against erosion. These data indicate that Cerro Negro Formation chert has a scattered distribution within the Sierras Bayas, but where it is found it has a high availability, is abundant, has excellent knapping quality, and is easily located for acquisition and exploitation. These quarries have a great internal variability in relation to rock characteristics (e.g., size, texture, color, and shape).

Limestone from the Loma Negra Formation constitutes a very homogeneous stratum (Poiré and Spalletti 2005), not entirely exposed in the Sierras Bayas, and identifiable in contemporary quarries (Figure 2(b) and (c)). Even though this rock does not have good knapping qualities, some debris and limestone tools have been recorded at some hill sites (Messineo 2008, 2011), showing the local exploitation of this resource. Moreover, at the Calera site, located in the vicinity of the acquisition source, two limestone natural slab levels were found separating different occupation events (Politis et al. 2005).

Procurement Modes and First Exploitation Stages

In order to understand procurement modes (i.e., selection processes) and the first stage of exploitation of lithic raw materials in quarry workshops and workshops, we analyzed the knapping gestures carried out during the production of stone tool artifacts (Pelegrin 1995). By studying cores and debitage corresponding to the first stage of the reduction sequence, we expect to understand the steps that followed in lithic manufacture, establishing the different stages of the *chaîne opératoire* at the analyzed sites through *objectifs de production* (*sensu* Leroi Gourhan 1943). For the analysis of cores, debitage, and tools, we considered morphological and technological attributes, as proposed by several authors (Andrefsky 1994; Aschero 1983; Aschero and Hocsman 2004; Cobb and Webb 1994; Pelegrin 1995).

In the hill sector, many sites related to procurement areas have been detected, such as Cerro Núcleo Central 1 and 2, El Mirador, Cerro Aguirre, Cerro Tres Lomas 1, Boca de la Sierra Taller, and Malegni (Figure 3), where exploitation and acquisition of several lithic raw materials were recorded. In the following section, we describe studies carried out at three archaeological sites. The first two refer to Cerro Largo Formation chert workshops and the other to Villa Mónica Formation silicified dolomite quarry workshop, all located near the outcrops. We have selected these three sites because they have a techno-morphological study in which the *chaînes opératoires* were analyzed for the whole lithic material (Barros 2009; Messineo 2008). Recently, a new quarry workshop site called Boca de la Sierra has been studied in detail; even though the information has been presented in another work (Barros et al. 2014), the results will be utilized in the discussion.

Chert Workshops

Cerro Núcleo Central 1 and El Mirador sites constitute superficial contexts as road constructions held by mining companies have exposed archaeological materials previously in A horizon of soil (Figure 3). This soil, approximately 1-m thick

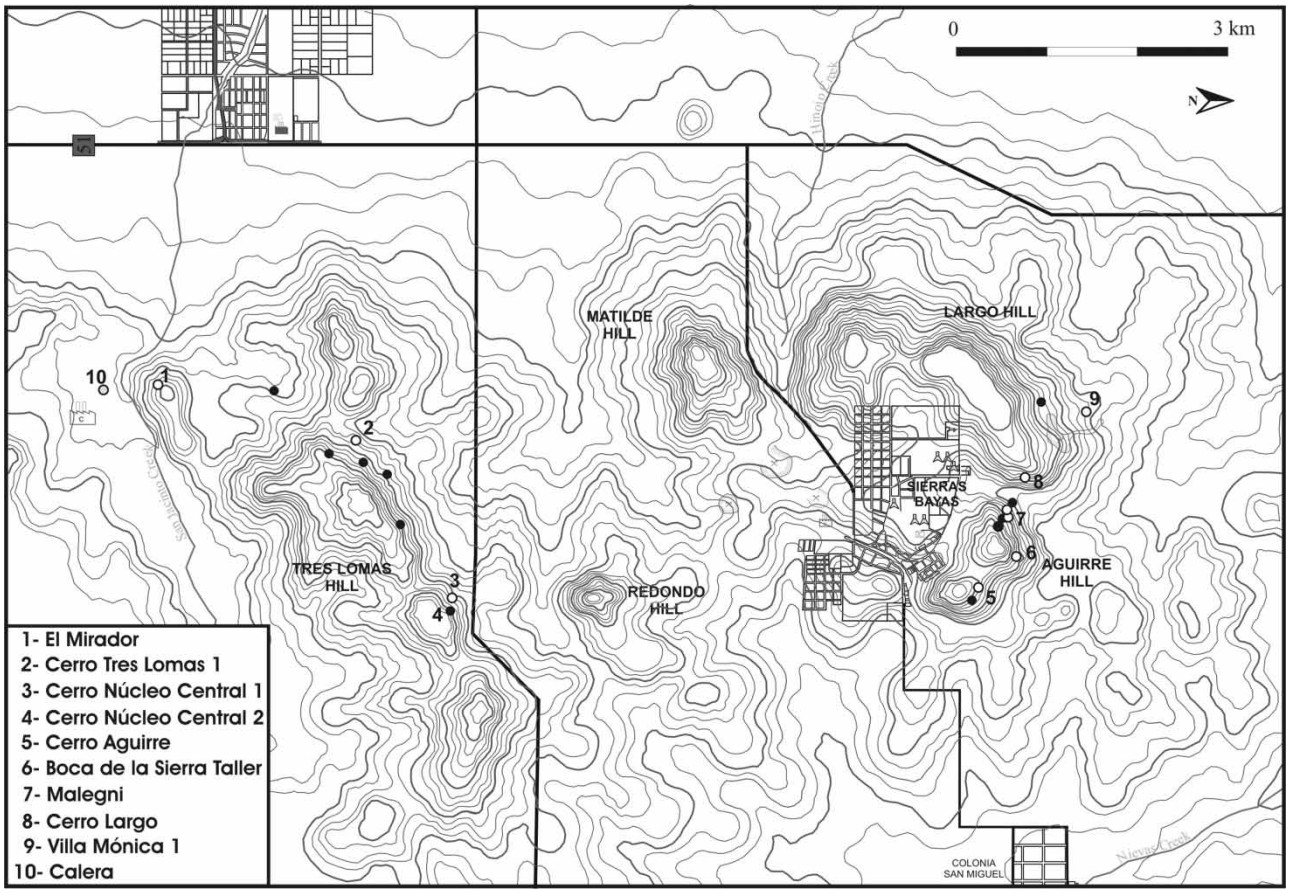

FIGURE 3. Sites mentioned in the text (map of the Sierras Bayas hills, see Figure 2(c)). The block dots correspond to chert and silicified dolomite outcrops.

covering hill slopes, corresponds to eolic deposits belonging to the La Postrera Formation that developed during almost the entire Holocene (Favier Dubois 2006). At both sites, the predominant raw material is the Cerro Largo Formation chert (ca. 90%), while orthoquartzites from the Sierras Bayas Group (ca. 7–9%), limestone, and macroscopically unidentified rocks were recognized in low percentages (Table 1). Flakes and debris are the most abundant artifacts (ca. 84–88%). At Cerro Núcleo Central 1, these are followed by unmodified nodules and tools, cores, utilized flakes, and tested nodules; while at El Mirador, flakes and debris are followed by cores, unmodified nodules, tested nodules, and tools. Unmodified nodules, tested nodules, and cores are present in higher frequencies at El Mirador than at Cerro Núcleo Central 1; while tools have a higher percentage in Cerro Núcleo Central 1 (Table 1). For this analysis, only the predominant rock in both contexts was taken into account (i.e., chert), since the remaining raw materials were generally introduced as tools and debitage.

CORES

At Cerro Núcleo Central 1 site, tested nodules and unmodified nodules are only made of chert, while at El Mirador site 91.3% of the materials are made of chert and the remaining 8.7% is made of orthoquartzite (Table 1). Complete cores at both sites correspond to flake cores; only one of which—from Cerro Núcleo Central 1—has long, parallel, and regular flaking extractions (blade-like or incidental elongated products) (Figure 4). Cores were made from nodules with several potential percussion platforms and there is only one from an external flake. In almost all cores (ca. 70%), platforms are flat and less frequently external (some surfaces correspond to coated fault-planes that are perceived as cortical). The knapping method in all cases was unipolar. Among core types, we recorded the presence of some with isolated blows (flaked nodules with at most two or three flakes detached without any initial preparation), pyramidal, and undetermined (following Aschero 1983). Sixty per cent present two exploitation platforms (bidirectional

TABLE 1. ARTIFACT CATEGORIES FOUND IN CHERT AND SILICIFIED DOLOMITE WORKSHOPS

Cerro Núcleo Central 1 site					
Categories	Orthoquartzite	Chert	Unidentified	Total	%
Flakes	18	275	–	293	71.64
Debris	8	56	1	65	15.90
Tools	5	11	–	16	3.91
Utilized flakes	–	2	–	2	0.49
Cores	–	10	–	10	2.44
Core fragments	–	5	–	5	1.22
Tested nodules	–	2	–	2	0.49
Unmodified nodules	–	16	–	16	3.91
Total	31	377	1	409	100
Percentage	7.58	92.18	0.24	100	–

El Mirador site					
Categories	Orthoquartzite	Chert	Limestone	Total	%
Flakes	19	161	2	182	65.23
Debris	2	49	1	52	18.64
Tools	1	1	–	2	0.72
Cores	1	12	–	13	4.66
Core fragments	–	7	–	7	2.51
Tested nodules	1	10	–	11	3.94
Unmodified nodules	1	11	–	12	4.30
Total	25	251	3	279	100
Percentage	8.96	89.96	1.08	100	–

Cerro Tres Lomas 1 site						
Categories	Orthoquartzite	Silicified dolomite	Chert	Granite	Total	%
Flakes	19	1880	24	1	1924	58.08
Debris	15	1268	6	–	1289	38.91
Tools	–	17	3	–	20	0.60
Utilized flakes	–	13	2	–	15	0.45
Use-modified tools	4	–	–	–	4	0.12
Cores	–	27	2	–	29	0.88
Core fragments	–	13	2	–	15	0.45
Tested nodules	1	14	1	–	16	0.48
Unmodified nodules	–	–	1	–	1	0.03
Total	39	3232	41	1	3313	100
Percentage	1.18	97.55	1.24	0.03	100	–

extractions), represented in almost all cases by unexhausted cores and with isolated blows, by presenting independent and/or opposed debitage surfaces (Barros 2009). The remaining cores have one and three percussion platforms (unidirectional and multidirectional scars, respectively) (Figure 4). Some of the cores were abandoned before being totally exploited, and 80% showed cortical surface remains in different percentages (from 5 to 60%). Finally, broken and hinged terminations were among the problems or accidents related to reduction and abandonment.

TOOLS

All the tools were unifacially retouched, being the retouch marginal. Tools with very thick sections were made on flakes (external and internal), nodules, and unknown artifacts. In Cerro Núcleo

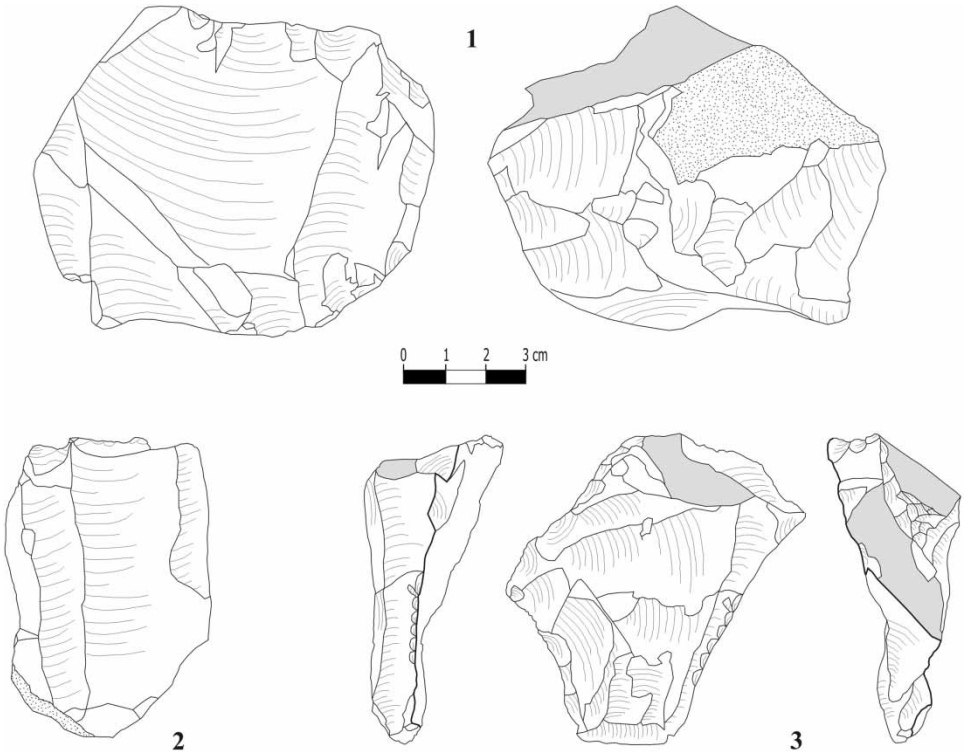

FIGURE 4. Cores and flakes from chert workshops; (1) core in chert with multidirectional scars, CNC1 site; (2) core in chert with blade-like extractions, CNC1 site; (3) *outrepassé* flake in chert, El Mirador site. The gray part represents interior fault-planes coated like cortex.

Central 1, the best represented tool type is the end-scraper (Figure 5(6–7)), followed by retouched flakes, expedient unifacial tool flakes, notches, burins, and tool fragments (Table 2). Two hammerstones and two utilized flakes were also recognized in the assemblage.

DEBITAGE

In Cerro Núcleo Central 1 site, distal flake fragments predominate (41.45%), followed by proximal flake fragments (33.45%), and complete flakes (25.1%). In El Mirador site, similar percentages for complete and distal flake fragments (41 and 40.4%, respectively), and low frequencies of proximal flake fragments (18.6%) were recorded. Taking into account only complete and proximal flakes, in Cerro Núcleo Central 1, cortical flakes have the highest percentages (ca. 35%), followed by angular (ca. 31%), ridged (ca. 24%), undifferentiated (ca. 5%), and plain (ca. 4%). At El Mirador site, cortical flakes predominate (ca. 56%), followed by angular (ca. 20%) and ridged flakes (ca. 19%). Core rejuvenation flakes in both assemblages are present in very low percentages and no bifacial thinning flakes were recorded (Table 3). Finally, at El Mirador, an *outrepassé* flake associated with core rejuvenation was identified (Figure 4). A 30.8% of internal debitage from Cerro Núcleo Central 1 presented cortex remnants, while at El Mirador, the frequency is 66.7%. In Cerro Núcleo Central 1 site, the most frequent types of platform are flat (ca. 46%) and cortical (ca. 17%), while at El Mirador, the most abundant platforms are cortical (ca. 45) and flat (ca. 34%). The remaining types (dihedral, linear, faceted, and pointed) are present in low frequencies and fractured platforms were also identified on flakes (Table 3). Platform preparation in both sites, such as grinding and nibbled, was recorded in low frequencies (ca. 12%).

SILICIFIED DOLOMITE QUARRY WORKSHOP

Cerro Tres Lomas 1 site constitutes a stratified context (2 m^2 area was excavated) and it is located less than 2 km away from the chert workshops (Figure 3). Geological and geomorphological studies were carried out by Favier Dubois (2006). The highest frequency of archaeological material was found in a well-structured A horizon of soil (Unit I), and this unit would have involved a long formation period during the Late Holocene. The most abundant raw material in the quarry

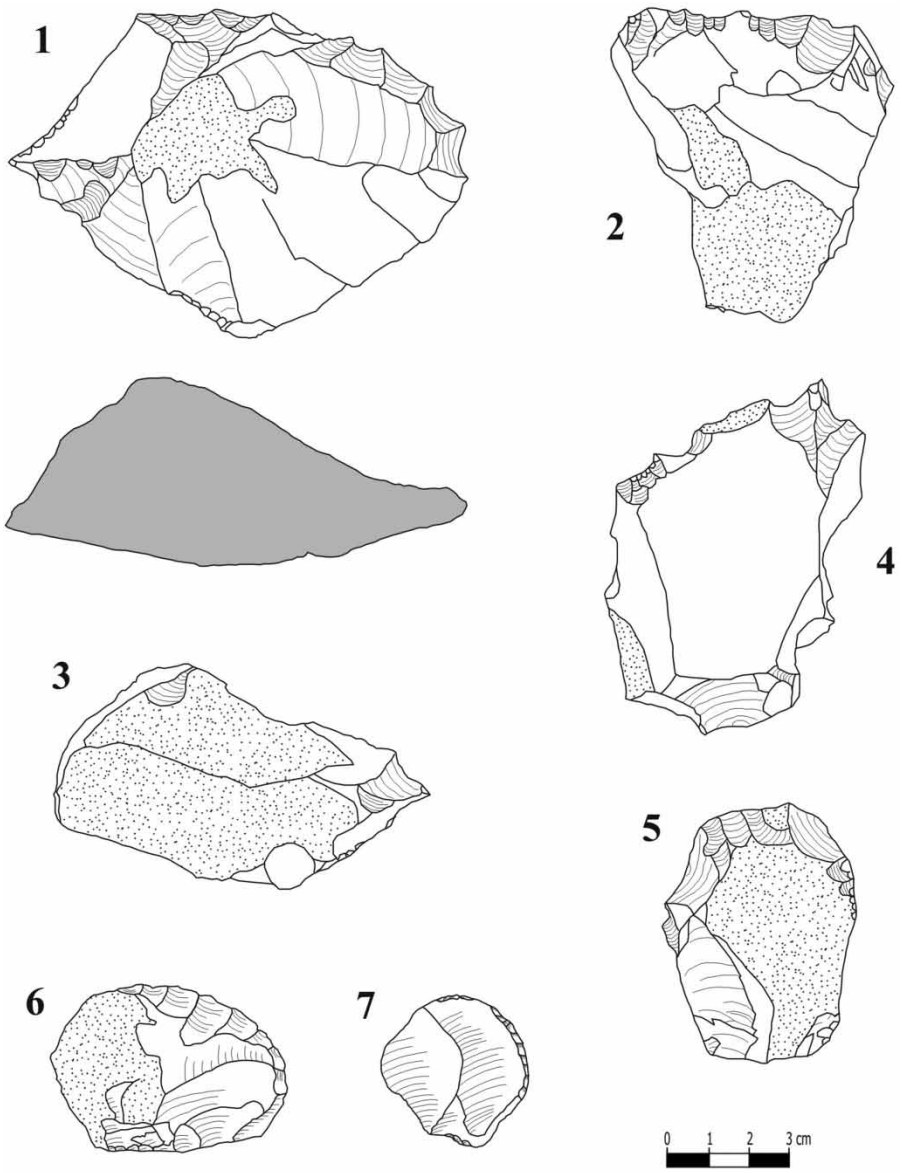

FIGURE 5. Tools; (1) thick end-scrapers—*cepillo*—in silicified dolomite, CTL1 site; (2) end-scraper in silicified dolomite, CTL1 site; (3–4) graver and notched point in silicified dolomite, CTL1 site; (5) end-scraper in silicified dolomite, CTL1 site; (6–7) end-scrapers in chert, CNC1 site.

workshop is the Villa Mónica Formation silicified dolomite (ca. 98%), followed by low percentages of the Cerro Largo Formation chert, orthoquartzite, and granite. In this case, only the technomorphological analysis of the most abundant rock in the assemblage will be presented in the following paragraphs (i.e., silicified dolomite), because the rest of the rocks were found at low frequencies, mostly as flakes and debris.

According to stone artifact categories, flakes are the most abundant (ca. 58%), followed by debris and shatters (ca. 39%), and finally, cores, tools, utilized flakes, tested nodules, and irregular and small-sized unmodified nodules in low percentages (Table 1). In silicified dolomite, ca. 9% of the artifacts presented evidence of thermal treatment, which was recorded on flakes, debris, tools, and cores (Barros and Messineo 2006). Although this may be associated with a technique for improving their quality, Pérez (2010) considered that the stone alterations could be related with hearth's contexts.

CORES

At the site, 27 complete silicified dolomite cores, 13 core fragments, and 14 tested nodules were found (Table 1). Most of the complete cores had the best stage of silicification (ca. 74%). They

Table 2. Tools found in quarries and workshops

Tool types	Cerro Tres Lomas 1	Cerro Núcleo Central 1	El Mirador	Total	%
Retouched flakes	–	1	1	2	4.26
Cepillos (thick end-scraper)	2	–	–	2	4.26
Notches	2	1	–	3	6.38
Multipurpose	6	1	–	7	14.89
End-scraper	2	4	–	6	12.77
Tool fragments	–	1	–	1	2.13
Unifacial flake tools	2	1	–	3	6.38
Notched points	1	–	–	1	2.13
Gravers	1	2	–	3	6.38
Burins	1	–	–	1	2.13
Utilized flakes	13	2	–	15	31.91
Hammerstones	1	2	–	3	6.38
Total	31	15	1	47	100

correspond to flake cores and only one is bipolar. They were made mostly of nodules (63%), flakes (11.1%), blocks (7.4%), pebbles (7.4%), slabs (3.7%), and undifferentiated blanks (7.4%). In the case of flake cores, the ventral face was used as a percussion platform. The cores presented mainly flat platforms (59.26%), followed by cortical (25.93%), and other types (14.81%). Most of the cores were worked by unipolar direct percussion with a hard hammerstone, and a small

Table 3. Frequency and percent of flake and platforms types (only complete and proximal flakes were considered)

	CNC1 chert		El Mirador chert		CTL1 silicified dolomite	
	n	%	*n*	%	*n*	%
Flake						
Cortical	57	35.4	54	56.25	750	54.38
Angular	50	31.06	19	19.79	226	16.39
Ridged	38	23.6	18	18.75	225	16.32
Plain	6	3.73	–	–	54	3.92
Bifacial	–	–	–	–	9	0.65
Core rejuvenation	2	1.24	5	5.21	21	1.52
Undifferentiated	8	4.97	–	–	94	6.82
Total	161	100	96	100	1379	100
Platform						
Cortical	28	17.39	43	44.79	507	36.77
Flat	74	45.96	33	34.38	599	43.43
Dihedral	14	8.70	8	8.33	62	4.5
Faceted	5	3.11	5	5.21	8	0.58
Linear	10	6.21	1	1.04	62	4.5
Pointed	4	2.48	1	1.04	18	1.3
Fractured	19	11.80	4	4.17	69	5
Unidentified	7	4.35	1	1.04	54	3.92
Total	161	100	96	100	1379	100

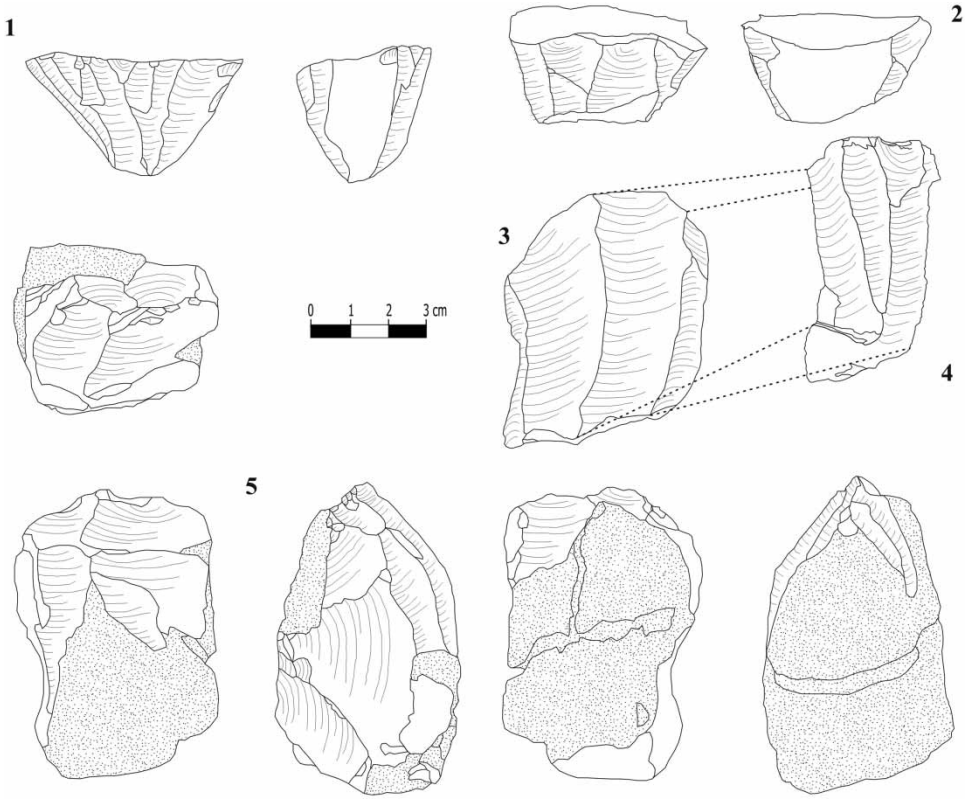

FIGURE 6. Silicified dolomite cores from Cerro Tres Lomas 1 site; (1) pyramidal core; (2) core with unidirectional extractions; (3) polyhedric core with bidirectional blade-like scars; (4) blade-like flake refitted in the core; and (5) cores with two exploitation platforms represented by opposed surfaces.

percentage were worked by the anvil technique (presence of crushed on the opposite side of the core), mainly when blocks do not present a flat surface (Barros 2009).

Among flake cores, those with isolated flaking scars were the most frequent (66.7%), followed by globular (7.4%), bifacial (7.4%), polyhedric (7.4%), and then pyramidal, prismatic, and bipolar (3.7%) ones (*sensu* Aschero 1983). One of the polyhedric cores has bidirectional blade-like flaking scars (Figure 6(3)). The 44.83% of cores have two exploitation platforms represented by independent debitage surfaces, but opposed surfaces are also present to a lesser extent (Barros 2009). These cores were worked by unipolar series from which wide and short flakes were obtained. In one-percussion-platform cores (34.48%), the surface is generally flat, and short and wide extractions are in some cases identifiable on the periphery (Figure 6(2)), but they rarely show blade-like extractions. The remaining cores have three or more percussion platforms (20.69%) worked with extraction series of long and parallel scars, and each debitage surface serves as the next percussion platform surface (Barros 2009). Finally, ca. 93% of analyzed cores presented different proportions of cortex, and large ones were abandoned before being totally worked, because of identified manufacture problems (e.g., broken and hinged terminations).

TOOLS

All the tools were unifacially manufactured. The retouch was marginal. Tools were made on interior and cortical flakes (82.3%), nodules and slabs (11.8%), and unidentified artifacts (5.9%). Tools are made on thick (large flakes) and thin flakes, and were modified by marginal unifacial retouch, mostly on all edges, but in some cases, the retouch was discontinuous. Within the assemblage, diverse kinds of tools were found such as end-scrapers, thick end-scrapers -*cepillos*-, notches, unifacial flake tools, burins, notched points, and gravers (Figure 5(1–5)). Some of the pieces are multipurpose tools, because they exhibit different patterns of retouch (e.g., thick end-scraper + burin). Also, we recognized a hammerstone in silicified dolomite that was utilized first as a core. Finally, a high frequency of possible utilized flakes was

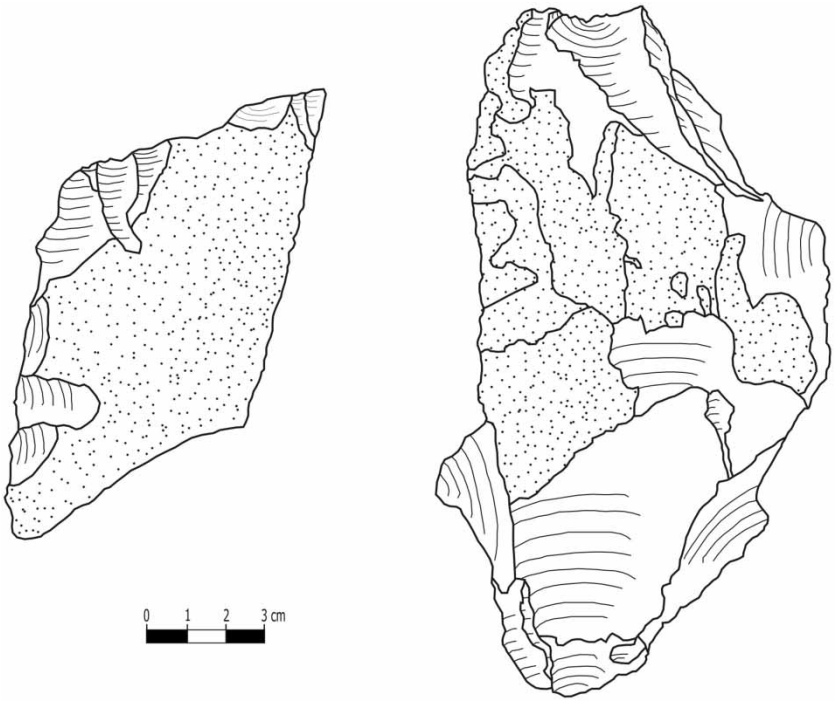

FIGURE 7. Slab tools made in silicified dolomite.

found in the assemblage (Table 2); however, use-wear analyses performed on these pieces did not provide conclusive results, because edges were completely modified by sedimentary abrasion.

Two artifacts with cortex remains were removed from slabs or thick plaques (Figure 7). Extraction scars that were identified on these objects could correspond to detached flakes; that is, they may have served as cores. However, when comparing all the cores and knapping products, there was no correspondence to the flake scar types that were identified on these artifacts. It is thus inferred that those extractions could have been done when these slabs were used as levers in order to extract other rocks from the outcrops (Barros 2009).

DEBITAGE

Complete flakes predominate within debitage (53.2%), and are followed by distal (26.6%) and proximal flake fragments (20.2%). Techno-morphological analysis of complete and proximal flakes shows that the most frequent types are cortical (ca. 54%), followed by angular and ridged ones (ca. 16% each). In lower percentages, undifferentiated (ca. 7%) flakes are present, while the remaining types show minor percentage values (Table 3). Additionally, ca. 57% of internal flakes have cortex remains, suggesting a strong incidence of first reduction stages at the site (Barros and Messineo 2006; Messineo 2008). Flat (ca. 43%) and cortical (ca. 37%) platforms are the most frequent types, showing that these surfaces were worked without being prepared or with a minimal preparation (as in the case of flat platforms). The remaining types are present in low percentages (Table 3). In 15.56% of platforms, some kind of preparation was identified, especially in dolomite with the best silicification stage. Among these, we recorded grinding, nibbled, and the combination of the mentioned traces.

KNAPPING STRATEGIES IN QUARRY WORKSHOPS

During the survey in the hills, we noted in general that the Cerro Largo Formation chert outcrops in all the hills, is easily accessible, abundant, and was highly available, probably involving a short time for searching, procuring, and transporting of the best knapping quality rock. Nonetheless, silicified dolomite is restricted to a few outcrops and its quality is very variable due to different silicification stages. In Cerro Tres Lomas 1 site, it was observed that the best silicification stage—the least abundant in the outcrop—is present with the highest percentage among worked materials, thus indicating that human groups that used the quarry workshop invested greater time and effort in searching, testing, and initially reducing best knapping quality rocks. These differences and the studies done on chert and silicified dolomite

suggest several modes of selection of raw materials in quarries and of reduction strategies, manufacture and rock circulation in the region.

By determining the production sequence, we are able to identify the activities carried out at the sites, including those related to selection, acquisition, and testing of nodule and block, as well as cores exploitation (i.e., first stages of lithic reduction sequence). In all the sites, testing was an important activity in order to find out the knapping quality of the stone. For chert, nodules with appropriate shapes and volumes were worked with no previous preparation by unipolar reduction and direct percussion with a hard hammerstone. On the other hand, size, shape, and the silicification stage of dolomite blocks/nodules were important variables in selection and exploitation. In some cases, irregular and small-sized nodules/blocks were not tested, but when they had enough volume, they were reduced. When they presented a flat cortical surface, it was used as a percussion platform, and the technique applied was direct percussion. But when blocks do not present a flat surface, the anvil technique was used, instead (Barros 2009).

Most of the analyzed cores did not present platform preparation. Percussion platforms correspond to cortical and flat surfaces, which are also the case of most of the debitage. Among cores, changes in the percussion platform surface or platform orientation and the worked surface during knapping (cores with bidirectional and multidirectional extractions) were observed. In relation to the reduction type, it was detected that the unifacial technique was applied to all cores and flakes; however, in silicified dolomite, bifacial technique was also recorded (bifacial cores in good quality Cerro Largo Formation chert were recorded in Boca de la Sierra workshop, see Barros et al. 2014: Figure 5(e–g)).

Another task performed at these sites was flake production with the aim of manufacturing different kinds of tools. In chert workshops, nonstandardized flakes (flakes with different thicknesses, sizes, and shapes) were obtained; while in silicified dolomite quarry workshops, both short and blade-like nonstandardized flakes were identified. Some flakes were marginally retouched for the production of certain tools (e.g., end-scrapers, thick end-scrapers *-cepillos-*, burins, notched points, and gravers), while some others were selected to be directly used. The presence of these tools suggests that other activities, not directly related to procurement, would have been also performed at these sites. However, use-wear analyses performed by Pal (personal communication, 2009) did not show any diagnostic features associated with the tasks carried out at these sites, because the tool edges were completely modified by sedimentary abrasion and soil sheen.

Finally, it is proposed that both raw materials could have been transported from quarries and workshops to other sites in the form of nodules, cores (e.g., with isolated flakes, globular, polyhedric, pyramidal, and bifacial ones), large flakes, and possibly tools. Barros et al. (2014) show that in sites located at a short distance from the quarries and workshops, good quality chert arrived as natural nodules (unmodified), which were decorticated *in situ* and as cores, confirming this kind of transport (Messineo 2011). Also, the presence of grinding preparation in some flake platforms shows that prepared cores (absent from workshops) were transported to other sites. And when considering silicified dolomite, the ones with better knapping quality may be transported.

Quarry Access and the Social Context of Exploitation

Procurement modes of lithic raw materials and the way they are exploited and used, depend on several factors: rock distribution in the landscape, accessibility and distance to quarries, exploitable rock abundance, mechanical qualities, and social factors (Beck and Jones 1990; Beck et al. 2002; Binford 1979; Dibble 1991; Ericson 1984; Gould 1980; Nelson 1991; Reher 1991; Topping 2011). It has been proposed that hunter-gatherer groups apply different strategies in order to access available raw materials, such as embedded (*sensu* Binford 1979) and direct strategies (*sensu* Gould and Saggers 1985), although these are not mutually exclusive situations.

Taking into account the characteristics observed in quarry workshops and workshops analyzed in the present paper, as well as other archaeological contexts from the Pampa grasslands, we propose that the different procurement strategies could be applied during the Late Holocene. On the one hand, hunter-gatherer groups that inhabited in areas near the quarries may have had direct and frequent access to these outcrops, where they acquired a great variety of rocks and minerals since there were no distance limitations. These groups, with their territories within a local exploitation radius may have applied the embedded strategies and special trips simultaneously. Even though rock access and procurement may be done more

frequently by individuals who performed direct trips to quarries by using logistical mobility, a possible procurement during other subsistence tasks (e.g., hunting in the proximity to outcrops and gathering of edible and medicinal vegetables in the hills) cannot be excluded since raw materials in the quarries present shapes and volumes that make them easily acquired and transported, and its acquisition may be carried out by different members of the band (i.e., men, women, and children). In both cases, hunter-gatherer groups must install short camps near the quarries, such as Boca de la Sierra and La Virgen rockshelters, which are located on the top of the Sierras Bayas hills.

On the other hand, human groups occupying territories far from procurement areas may have applied other strategies to access and acquire these resources. Rocks have been obtained as part of the annual range of mobility to exploit the diverse environments of the region and by direct trips to quarries through logistical mobility, possibly by people who were specialized in knapping activities (see example for the Pampean region in Bayón and Flegenheimer 2004). In some archaeological sites located far away from outcrops (more than 100 km), a greater energy investment in the core preparation in the case of the rocks of better quality during procurement was identified. In the same way, large-sized prepared cores were recorded at sites located mid-distance to quarries (between 40 and 100 km away), nearby, and in workshops (Colombo 2011; Flegenheimer et al. 1996; Martínez and Mackie 2003–2004). Further, the rocks could be obtained through social exchange and interaction networks with those groups that managed the right of access and exploitation in quarries (Bayón and Flegenheimer 2004; Messineo 2008).

The northwest Tandilia System represents the final outcrops (from east to west; Figure 1) of a wide variety of high-quality rocks for tool making by flaking and chipping, abrasion, and polishing (granite), mineral pigments and claystone, for human groups that occupied different areas of the region, especially those located north and west, that lacked those materials. Following Saunders (2004), these places in the landscape where certain resources are concentrated could have functioned as areas of great cultural significance in the past, being places where bands got from different territories performed alliances associated with exchange and ceremonial activities, which could have involved different generations and groups through time (Edmonds 1999; McBryde 1984; Paton 1994; Politis et al. 2005; Ross et al. 2003). The activities in these places are conducted by different social agents depending on economic, cultural, ideological, and symbolic factors, where a complex network of kinship relationships, reciprocity rules, social identities, group affiliation, and political leaderships was shown, all in turn affecting other activities (Bradley 2000; Paton 1994; Topping 2011). According to Ross et al. (2003), exchange carried out in these sites or nearby took place within a social context of ceremonial activities between bands where food resources were shared and distributed.

In this context, Calera site (Figure 3), located in an intermontane valley near the previously described quarries and workshops (between 1 and 5 km away), has been interpreted as an exceptional context constituted by offerings and ceremonial trash deposited in pits related to ritual origin, probably produced as the result of several ceremonies performed during band aggregation periods in the Late Holocene, between ca. 3400 and 1750 ^{14}C years BP (Politis et al. 2005). The site's ceremonial context is based on the quantity and variety of archaeological material related to the ideational sphere (e.g., a carved plaque, a polished axe, a shell bead, a decorated guanaco stone, ceramics with figurative motifs, and certain carnivore species), resources coming from other areas of the region (e.g., sea shells, mineral pigments, some lithic tools, and ceramic motifs), structural complexity of the site (e.g., intentional excavated pits, slab levels that separate occupation events, faunal assemblages delimited by stones and grouped guanaco skulls), and the restricted seasonality of different site occupations (spring–summer).

At this site, local chert (mainly as debitage and cores), nonlocal orthoquartzite (principally tools), and other lithic raw materials were deposited in these pits. Among mineral pigments, local and nonlocal resources may have been used in ceremonial activities (e.g., body painting, leather painting, and ceramic decoration) as a product of their ideational component (Matarrese et al. 2011), which has been documented among different indigenous groups in ethnohistorical and ethnographic sources (Taçon 2004). Band aggregation in Calera site to partake in festive and ritual feasts possibly allowed groups that occupied territories far away from the hills to acquire a wide variety of lithic and mineral raw materials through exchange for other utility and prestige resources (e.g., goods, people, and information), intensifying intergroup

relationships and alliances during a period when territoriality in the Pampean region conditioned the direct exploitation of different environments.

Raw Material Circulation in the Center of the Pampa Grasslands

Investigations in the Pampean region provide an important framework for analyzing change over time in technological strategies developed by hunter-gatherer groups. The archaeological evidence found by different authors shows a shift from more mobile human groups in the Early Holocene toward less mobile groups in the Late Holocene. During the last period, a reduction in the residential mobility and the increase of territoriality among hunter-gatherers groups, as well as changes in the use of the landscape, which is linked to an increase in population density and complexity of these groups (Bayón and Flegenheimer 2004; Martínez 2006; Mazzanti 2006; Messineo 2011) were observed. These variables have been important factors in technological changes observed in the center of the Pampa grasslands.

In some archaeological sites located less than 45 km from northwest area of the Tandilia Hills System (e.g., Laguna La Barrancosa 2, Arroyo Tapalqué 1, Blanca Chica, Calera, and the upper levels of El Puente sites), a predominance of local chert was found, as well as a representation of all the stages of the *chaînes opérotoires* (Messineo 2011; Messineo et al. 2014). Barros et al. (2014) have observed that chert arrives at these sites as natural nodules that were decorticated *in situ* and as cores partially decorticated, generating, along the reduction sequence, a series of external and internal flakes that are linked to the early stages of the reduction sequence. Also, most of the chert tool production corresponds to the *chaîne opérotoire* organized through *débitage*, with low production of standardized flakes used as blank for the manufacture of tools. A high frequency of flakes has been used as natural edges without any retouch, while in other cases, we observed the manufacture of different types of tools among which are highlighted flakes with edge-retouched, end-scrapers, knives, unifacial edges, and multipurpose tools (Pal 2012). All this information suggests the employment of an expedient technological strategy on chert that involved the wide variability in core reduction, the lack of standardization in the manufacture of tools with limited modification, and labor investment (Barros et al. 2014).

On the other hand, local silicified dolomite is identified in very low percentages in the archaeological contexts mentioned, except El Puente site, which has ca. 10 per cent of this material and mostly demonstrating thermal treatment (Messineo 2011), and Curicó rockshelter site where several triangular projectile points manufactured on this rock were found (Pedrotta 2005). Although silicified dolomite has good knapping qualities, restricted outcrops in the hill area and the way it appears in quarries (nodules with different silicification stages) were some of the variables that influenced the low representation of this rock in the center of the Pampa grasslands (Barros and Messineo 2006; Messineo 2011). Moreover, other local rocks (e.g., granite and orthoquartzite of the Balcarce Formation) were used in low percentages in the manufacture of furniture tools made by chipping, abrasion, and polishing (e.g., anvils, hammerstones, grindstones, and pestles).

When considering nonlocal rocks to the center of the Pampa grasslands, in most sites, orthoquartzite of the Sierras Bayas Group has a secondary importance and the acquisition of this rock may involve the annual range of mobility. In these assemblages, a higher proportion of standardized and shaped tools (e.g., side scrapers with long edges), bifacial and exhausted bipolar cores associated with raw material maximization, bifacial thinning flakes, and small-sized debitage with no cortex are identified. Micro-wear analyses indicate that orthoquartzite tools have versatile edges that allow the developing of different functions and the processing of a wide range of materials, such as wood, bone, and hide (Pal 2012). Moreover, in La Barrancosa lagoon, a cache and large-sized orthoquartzite cores were recorded, which may have functioned as lithic raw material reservoir in those landscape areas where these resources were not available (Messineo 2011). Finally, the low frequency of exotic raw materials from distant resources (e.g., central-west of La Pampa province, the Ventania Hill System, and the Buenos Aires coast), and mainly represented by finishing tools, suggests that the acquisition may be done through social exchange and interaction networks among hunter-gatherer groups that occupied different territories (Messineo 2011).

Conclusions

In this paper, we have concentrated on lithic technology, and particularly, in the manner in which lithic raw materials were obtained and

exploited in quarry workshops. We have found through our research in the northwest Tandilia hills that local raw materials selection (chert versus silicified dolomite) and first stages of lithic reduction sequence were conditioned by the availability, abundance, and mechanical properties to produce diverse types of tool stones. Chert and silicified dolomite may have been transported from quarry workshops to other sites in the form of nodules, different kinds of cores (expedient technology), and large flakes. In relationship with tactics of acquisition and mobility, an embedded strategy for raw material acquisition in quarry workshops may have been done by individuals who performed other activities near the hills. However, direct trips to quarries by using logistical mobility may have been applied by hunter-gatherer groups that inhabited in the Pampa grassland (see Barros et al. 2014). During these trips to the northwest Tandilia hills, exchange could have taken place within a social context of ceremonial activities.

The data generated in this work suggest that during the Late Holocene, with the reduction of the residential mobility in hunter-gatherer societies and other variables (e.g., territoriality), the most exploited rocks in the center of the Pampa grassland were those located nearest the sites, in this case, local chert from the Sierras Bayas hills. These data, which contrast with those obtained from other areas of the Humid Pampa subregion, could be related to different mobility circuits that were used by hunter-gatherer groups and social exchange networks that included the groups that occupied several territories of this extended region.

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