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EL CONDOR MINE: PREHISPANIC PRODUCTION AND CONSUMPTION OF HEMATITE PIGMENTS IN THE ATACAMA DESERT, NORTHERN CHILE.

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Abstract:

The mineral richness of the Atacama Desert permitted the development of a diverse array of mining activities, including the production of metals, lapidary, and pigments, which developed into significant sociocultural practices for desert dwellers throughout the occupation of the region. El Cóndor mine is an important hematite source located in the middle section of the Loa River, exploited from the Formative Period (ca. AD 300) until Inca times (ca. AD 1500). In contrast to other mining sites of Atacama region, the El Condor mine complex contains specialized infrastructure where different kinds of activities were carried out: extraction pits, processing areas with multiple anvils and grinding tools, and semicircular structures used for domestic activities. Pigment production was initially developed as a small-scale craft that intensified during later periods (ca. AD 1200). It was most extensive following the Inca expansion (ca. AD 1400), as evidenced by wider networks of distribution and consumption, as well as infrastructural changes. El Cóndor mine constitutes a notable example of a large-scale hematite operation that articulated important networks of exchange, and as such provides a case study for evaluating the organization of mining activities during late periods of the pre-Hispanic sequence in the Atacama Desert. We then emphasize that the circulation of pigments constitutes an important social practice and a salient economic activity, fulfilling a political role through the production and reproduction of social relations between different cultural entities that could be compared to similar cases from other regions in the world.

Keywords: Iron Oxide; Mining; Color; Inca; Late pre-Hispanic periods; Andes region.

1. Introduction

The use of pigments as raw material, powder or processed mineral, is frequently cited as one of the most significant elements for the creation of symbolic behavior among human societies, particularly for modern humans (Barham, 1998; D'Errico et al., 2012; Henshilwood et al., 2011; Hovers et al., 2003; Rifkin, 2012; Taçon, 1999). Pigments have significant economic, political, and ideological implications (Ball, 2005; Gage, 1999; Young, 2006). Along with its functional, symbolic, decorative, and aesthetic value (Boivin, 2004; Roper, 1991; Saunders, 2004), the use of pigments contributes to individual and collective distinctions of status, roles, and identities (Barber, 1999; Boivin, 2004; Fiore, 2005, 2006; Jones and MacGregor, 2002; Young, 2006). In general, archaeologists discuss these different forms of consumption more often than pigment extraction, production, and distribution, practices also incorporated into a variety of social contexts throughout human history. Direct or indirect procurement, circulation, and exchange of pigments involved political negotiations that connected different groups through acts of reciprocity, tribute, and other types of social obligations. Hence, the circulation of pigments constitutes an important social practice and a salient economic activity, fulfilling a political role through the production and reproduction of social relations between different cultural entities (Appadurai, 1991).

In the South American Andes, fragments of mineral pigments have been found in archaeological contexts from the Late Pleistocene onwards (Llagostera et al., 2000; Prieto et al., 2016; Santoro et al., 2011), becoming more ubiquitous at the beginning of the Holocene (9000—1500 BC). Among hunter-gatherers of the Andean highlands, mineral pigment use has been associated with the treatment of animal skins (Aldenderfer, 1998; Popelka-Filcoff et al., 2007) and rock art production (Gallardo, 2009; Guffroy, 1999; Sepúlveda et al., 2012, 2013b; Yacobaccio et al., 2008). On the Pacific coast, powdered pigment has been found on stone tools used for grinding, in shells used as containers (Costa-Junqueira, 2001; Lavallée et al., 1999; Llagostera et al., 2000; Prieto et al., 2016; Salazar et al., 2015), on Chinchorro mummies, and as funerary offerings among the earliest maritime societies of the northern coast of Chile (Arriaza et al., 2008; Costa-Junqueira, 2001; Mostny, 1964; Sepúlveda et al., 2014; Uhle, 1919).

In later periods coinciding with the appearance of agropastoral and maritime societies on the coast, valleys, and highlands of the Atacama Desert, the consumption of pigment significantly expanded, and its remains have been recovered inside small woven bags, wooden boxes, ceramic vessels, and mollusk shells (Boman, 1908; Créqui-Montfort, 1906; Dauelsberg, 1974; Focacci, 1974; Hermosilla and Barrera, 2010; Latcham, 1910, 1938; Mostny, 1964; Spahni, 1967; Uhle, 1917, 1919). Commonly mixed with other components, pigments were also applied on a variety of materials such as ceramics, textiles, wood, metals, rock surfaces, and adobes recovered in domestic, ritual, and funerary contexts (Núñez et al., 2016; see also for Central Andean region: Bonavia, 1985; Prieto et al., 2016). The intensive and extensive presence of pigments indicates that there was a significant exploitation of non-metallic deposits or mineral veins to obtain raw materials for coloring a variety of material objects. These practices involved the organization of extractive activities conducted by small groups, or collectives with higher degrees of specialization, in order to

obtain and produce the amount of pigment necessary for both direct consumption and exchange (see also Eerkens et al., 2009).

In the Andes, like in other regions of the world (Levato, 2016), there are very few documented cases of pigment mining operations (Burger, 2013; Vaughn and Tripcevich, 2013), particularly the activities of extraction and processing. While part of a mining process analogous to the extraction of metals, these non-metallic sources have been scarcely studied archaeologically (Shimada, 2013). The cinnabar mines of Huancavelica in the Central Andes, exploited between the Early Horizon and the Late Intermediate Period (LIP), are an exception to this rule (Burger et al., 2016). Vaughn and collaborators (2013) also report the exploitation of a hematite mine during Nasca times. These references, in addition to the extensive use of pigment and the significant distances that these objects traveled (metallic artifacts painted with cinnabar from Huancavelica have been found at 800 km from the mine, for example), speak to the magnitude and importance of the exploitation and circulation of this material during pre-Hispanic times in the Andes region.

In the Atacama Desert archaeological studies of pre-Hispanic mining sites examine mineral mining, to identify in general the technological processes involved in the production of metal (Núñez, 2006; Salazar and Vilches, 2014), and other mineral sources, such as gypsum (Blanco et al., 2017), stones for lapidary production (Carrasco, 2002; Garrido, 2015; González and Westfall, 2008; Núñez et al., 2003; Rees, 1999; Rees and De Souza, 2004; Salazar et al., 2010, 2012; San Francisco and Ballester, 2010; Westfall and González, 2010), and pigments (Salazar et al., 2011, 2013a; Sepúlveda et al., 2013a, 2013b, 2014). The relevance of the last lies not only in its antiquity— dating to the Early Holocene, such as at the site of San Ramón 15 in Taltal (Salazar et al., 2011, 2013a)—but also in its ubiquity in archaeological settings, given that unlike metal deposits, sources of pigments, like iron oxide, are less localized and more evenly distributed throughout the region.

In a context where the presence of pigments has been overlooked, our aim is to highlight its social, historical, economic, and political importance. To that end, this paper presents the results of archaeological studies conducted at El Cóndor mine, located in the middle portion of the Loa River Valley in the Atacama Desert. We begin by offering a contextualization of the agropastoral society involved in the exploitation of the mine. El Cóndor is comprised of a series of extraction pits, processing areas, and a mining camp with multiple domestic units. Radiocarbon dates and archaeological materials obtained from excavations have permitted the definition of distinct periods of occupation, from the Formative Period (ca. AD 300) until Inca times (ca. AD 1500). Additionally, we provide a description of production sequences, and follow with a discussion of the economic and political implications of the mining operation at El Cóndor during later periods, particularly during the Inca expansion. The ceramic typology and the nature of foreign objects recovered at the site indicate that the local production was incorporated into a vast network of interaction and exchange, suggesting that pigments were consumed both locally and regionally. This pattern of consumption was modified during the Inca (or Late Period) as indicated by association to Inca roads and infrastructure. During this period new dynamics of negotiation emerged between local miners and state emissaries concerned with both meeting the local demand while filling tributary obligations. Embedded in a particular social topography characterized by a long tradition of exchange relations, El Cóndor mine contributes to our understanding of the social importance of pigment production, circulation, and consumption.

2. The social topography of the Atacama Desert

The Atacama is one of world's driest deserts. However, oases, valleys, and ravines are extensively and widely distributed throughout the region, offering specific resources. In the Antofagasta region, the Loa River—the only perennial stream that crosses the desert from the Andes to the Pacific Ocean, traversing almost 440 km (Fig. 1)—functioned as a natural corridor and an important locus of occupation for both human and animal populations.

In this region, the earliest human settlements date back to 12,000 BP, and included an important diversity of lifeways (Castro et al., 2016). Small groups of hunter-fishers inhabited the Pacific coast from the initial settlement of the area until the Spanish conquest. In the interior, valleys, ravines, and oases were initially occupied by mobile groups of hunters and gatherers, followed by societies whose subsistence depended upon the collection of wild resources, agriculture, and pastoralism (Castro et al., 2016).

Outside the spaces where residential occupations were concentrated, a multiplicity of activities took place, including the procurement of raw materials, and different stages in the processing of pigments. The product was then transported between population centers through a complex system of caravan and pedestrian routes. These networks facilitated the movement of people, animals, materials, food resources, and manufactured goods and supported a continuous flow of information that generated strong sociopolitical interactions between diverse areas, thereby creating a cultural mosaic (Ballester and Gallardo, 2011; Berenguer, 2004; Gallardo, 2009; Gallardo and Cabello, 2015; Gallardo et al., 2012; Núñez, 1984; Núñez and Dillehay, 1995; Pimentel, 2009 and 2012). Goods moving through these networks included ceramic vessels, textiles, food, baskets, ornaments, shells, wood, metal and bone artifacts, along with a large volume of metallic resources (copper, gold, silver), and non-metallic minerals (silica, obsidian, gypsum, clays, iron oxide). The presence of processed or natural red pigments found in archaeological sites from different periods, in residential, ceremonial, and funerary contexts, as well as in rock art, or applied on pottery, wood, rocks, and animal skins, denotes the important value, appreciation, and social significance of these coloring substances.

The use of the landscape varied greatly during pre-Hispanic times and among groups inhabiting different ecological regions. From the initial settlement of the region until the transition to agro-pastoralism, the Archaic Period (10,000—1500 BC) was characterized by social groups whose subsistence depended exclusively on hunting and gathering, with diverse settlements patterns and mobility strategies (Druss, 1976; Mena, 1984; Núñez, 1982; Núñez and Santoro, 1988). The Formative Period (1500 BC— AD 900) was marked by a reduction of residential mobility, the emergence of public architecture, the intensification and specialization of manufactured goods, and the development of circuits of long-distance exchange, which sparked emergent social distinctions and hierarchies (Agüero and Uribe, 2011; Agüero et al., 2006; Núñez et al., 2017; Sinclair, 2004; Uribe, 2009). During the Late Intermediate Period (AD 900—1400) distinctive cultural identities were materialized in the production of objects, particularly ceramics and textiles, which were exchanged in significant quantities across the region (Agüero, 2015; Berenguer, 2004; Thomas, 1978; Uribe, 2006; Uribe et al., 2007). A few decades before Spanish colonization, the Late Period

(AD 1400—1550) was defined by the Inca expansion, and the reconfiguration of local economies and social organization in order to meet new demands enforced by the imperial order (Cornejo, 2014; Uribe, 2004a).

3. El Cóndor Mine in the Atacama Desert

3.1. Archaeological survey and interventions

The modern city of Calama (2600 masl) is located in one of the largest oases along the Loa River valley, which offers extremely favorable environmental and physical conditions for human settlement. Ancient *algarrobo*, *molle*, and *tamarugo* forests proliferated prior to the formation of the town, concentrating an important amount of animal and plant resources. Starting in the Formative Period (ca. 1500 BC) human populations settled around the oasis, creating one of the main loci of pre-Hispanic occupation in the region (Boman, 1908; Crequi-Montfort, 1906; González and Westfall, 2010; Hermosilla and Barrera, 2010; Latcham, 1938; Núñez, 1965; Thomas et al., 1995; Uhle, 1912, 1913).

The communities of the oasis of Calama were connected to other population centers through ancient routes, specifically to Tarapacá and the Upper Loa River valley to the north, the Salado River to the east, San Pedro de Atacama to the south, and Quillagua and the Pacific to the west (Correa and García, 2014; Pimentel, 2012; Pimentel et al., 2011; Torres-Rouff et al., 2012). This last connection was one of the most important routes, and was transformed into the *Camino Real* between Cobija and Potosí in colonial times, connecting the region during the existence of the *Corregimiento de Charcas*, until the Republican Period in the 19th century (Borie et al., 2016; Larraín, 1977; Letelier, 2016). From Calama, the route traverses the desert heading west through the interfluvium of the Loa and the San Salvador rivers, reaching Chacance at the intersection of those streams, and turning south at Huacate (Fig. 1).

Through surveys conducted along this road, 227 archaeological sites have been documented. A variety of sites have also been recorded in an area of the interfluvium of approximately 26 km in length (11,000 ha), including geoglyphs, *apachetas*, ceremonial sites, roadside camps, waystations and *tambos*, as well as elements other than road infrastructure, such as lithic workshops, ephemeral settlements, agricultural terraces, and funerary sites (Torres-Rouff et al., 2012). Among these findings, an extensive area of hematite extraction was discovered around 16 km downstream from Calama and 50 km away from the confluence of the Loa and San Salvador rivers—subsequently named El Cóndor.

The mine complex has been systematically recorded, including areas of hematite extraction and processing and the residential sector. Surface collections have been carried out in order to obtain diagnostic material for the chronological and functional definition of spaces. The objects collected included pottery fragments, archaeobotanical and animal remains, and artifacts associated with mining activities, such as containers, hammerstones, mortars, pestles, and chisels. Fourteen units were excavated (4.3 m²) to explore deposit density, material diversity, functionality, stratigraphy, and the chronology of all the areas of the site. Samples for radiocarbon dating were taken from the different occupations. Additionally,

recovered minerals were sampled to conduct elemental and mineralogical physico-chemical analyses, and to provide a compositional characterization of the mine. This research is currently underway¹.

3.2. Geological Context

At approximately 2000 masl, El Condór mine is located between the Intermediate Depression and the Andean foothills, along the *Cordillera de Domeyko*. The mine is on a geological formation known as the Loa group, comprised by the *Llalquincha*, *Lasana*, *Miembro Quebrada Teca*, *Formación San Lorenzo*, *Angostura*, *Quebrada Opache*, *Quebrada Chiquinaputo*, and *Chiu Chiu* formations (May et al., 2005). This is a combination of geological conglomerates and sandstones of different epochs, ranging from the Lower Miocene to the Upper Pliocene (May et al., 2005). The complexity of the processes of sedimentation in the *Pampa del Tamarugal*—specifically in the Loa River Basin—is likely the result of multiple periods of climatic change and tectonic alterations during the Cenozoic and the Miocene. The combination of several geological processes (volcanic eruptions with certain mineralogical characteristics, variable cooling events, tectonic modifications, and interaction of alluvial flows) explains the mineral diversity (variable oxidizing processes) along the Loa River, as well as the irregular availability of mineral deposits in the area. These processes created three types of sources for potential human exploitation: 1) subterranean veins that required excavations and complex processes of extraction according to depth, orientation, and size; 2) mineral veins that emerged on the sides of ravines, with different degrees of accessibility depending on the gradient; 3) easily accessible rock outcrops located on plateaus or plains. El Condór mine corresponds with the second type of geological source.

3.3. Archaeological context

The highly visible red tailing that currently covers the slope of the Loa River ravine facilitated the identification of the mine. Pigment was extracted from three separate shafts located on the upper section of the northern side of the Loa River, 200 m above the stream (Fig. 2). The shafts, ranging from 1 to 3 m in diameter and of variable depth, are located along an iron oxide vein. The absence of infrastructure around the shafts makes their chronological associations highly difficult to establish (Fig. 3). The tailings and mining debris, which are the product of repeated and sustained extraction events, are dispersed over a surface of approximately 200 m² (Figs. 2 and 3). From the shafts, rocks were transported to the upper sector of the site for processing, following a zigzag trail for about 100 m towards the northern terrace.

At the edge of the ravine, three natural terraces with separate processing areas and domestic structures were identified, covering an area of approximately 2.6 ha (Fig. 4). A single-walled circular structure of dry stone masonry was found on the lower platform, along with a processing area with multiple pestles (Processing Area 5). In the middle platform, a limited sector for mineral processing was also found in association with abundant red powder (Processing Area 4). The upper platform is where most of the infrastructure of the site is located, including two habitational compounds and at least three areas for mineral processing.

In the upper platform, both residential complexes (Fig. 4) are associated with two processing areas (Fig. 5). The first one (Residential Area 1) is the furthest away from the extraction shafts, and consists of three semi-circular structures, between 1 and 2.3 m wide, adjacent to the side of the ravine (Fig. 6A). The second complex (Residential Area 2) is located 30 m to the SW—much closer to the extraction shafts—and is comprised of five circular units of 2.5 m in diameter on average (Fig. 6B). The structures in both areas are poorly preserved, and were built by piling up ignimbrite rocks. No other architectural features have been observed, such as doorways or windows. Continuous walls can be clearly distinguished in two enclosures of Residential Area 2 (Fig. 6B).

Three areas for mineral processing were found on the same platform (Processing Areas 1, 2, and 3) (Fig. 4). They are located around large ignimbrite blocks that were used as anvils, with multiple cavities with pestles and fragments of minerals (Figs. 6C and 7). These processing areas are larger than the ones identified on the middle and lower platforms (Processing Areas 4 and 5) (Fig. 4), and are distinguished through their association with other types of structures, at a wider distance from the extraction shafts.

A group of red pictographs was recorded on the western edge of the upper platform, painted on the wall of the ravine (Fig. 4). Despite their poor state of preservation, two painted panels of 3 m in length by 1.5m wide present a combination of geometric and checkered figures, as well as red stains with multiple superpositions (Fig. 8).

Excavations inside residential units recovered large concentrations of red powder in association with a low density of domestic remains, such as camelid and fish bones, shells, maize cobs, *algarrobo* pods, gourds, wooden artifacts, cordage made of animal fibers, lithic instruments and debitage, and ceramic sherds. Domestic contexts were identified in all the units excavated, characterized by hearths in association with domestic refuse, both above and below the layers with more density of processed pigment (Figs. 9A and 9B). A depth of 35 to 40 cm was recorded inside the Residential Area 1 units (Fig. 9A), while the depth inside one of the units excavated in the Residential Area 2 was between 60 and 70 cm (Fig. 9B), indicating larger occupational deposits. Lower densities of domestic refuse and separate stratigraphic layers inside these units suggest short but repeated occupations, probably related to logistical mining practices.

Three radiocarbon dates were obtained from the excavations conducted at the upper platform (Table 1). All samples were extracted from the base of hearths or the initial occupations (Residential Area 1, Units 8-8A, and Residential Area 2, Unit 9), below the strata with higher concentrations of mineral and powder associated with events of intense pigment processing (Figs. 9A and 9B). The radiocarbon dates—between cal. AD 365—523 and cal. AD 1385—1432—indicate that the occupation of the residential areas began during the Formative Period (400 BC— AD 900), and continued through the LIP (AD 900—1400), and the Late Period (AD 1400—1550). The earliest date comes from a layer without ceramics in the Residential Area 2 (Unit 9), which is located closer to the extraction shafts, and associated with lithics, camelid bones, and fragments of wood and cordage, strongly suggesting older occupations of this sector of the site. The presence of a shell of *Olivia peruviana* in the same stratum points to direct connections with the Pacific coast. Dates obtained from units 8 and 8A in the Residential Area 1 indicate domestic activities that can

be attributed to later periods of the pre-Hispanic sequence (Late Intermediate and Late periods). Shell fragments (especially *Choromytilus chorus*) and fish bones were also recovered, a manifestation of sustained connections with the coast of the Pacific.

The ceramic assemblage (Table 2; Fig. 10) reveals a predominance of the *Loa-San Pedro* component, associated with local groups inhabiting the highlands of the region during the Late Intermediate and Inca periods (n=514; 87.5 % of the sample). These are large containers used for food preparation and storage –Turi Rojo Alisado (TRA), Turi Gris Alisado (TGA), Turi Rojo Revestido (TRR), and San Pedro Rojo Violáceo (SRV) types-, as well as smaller vessels used for serving and consuming meals -Aiquina (AIQ), Dupont (DUP), and Turi Rojo Revestido Pulido (TRP) types- (Uribe, 2004b; Varela, 1992). In significantly lower proportions, there are specimens that can be directly associated with the Inca Period, identified by the introduction of Inca-style ceramics that were used alongside local types that had been continually produced since the LIP (n=18; 3% of the sample). Among them, modeled plates -Turi Rojo Revestido Pulido Ambas Caras (TPA), local jars as Lasana Café Rojizo Revestido Pulido Exterior (LCE), Inca imperial jars (INK), and Copiapó-style plates with black-over-red paint (CNSR) were recovered. The latter type (Figs. 9A-C) was produced 500 km away from the site during the LIP (ca. AD 1000), and its presence indicates that the site was part of a wide network of circulating goods (Uribe and Cabello, 2005). These types are followed by the *Indeterminado con Mica* style (IND-MICA=16; 2.7% of the sample) of the Late Period, which was continually used regionally until Colonial times. The historical fragments (HIS), on the other hand, are generally exceptional (n=2, 0.3% of the sample), and are followed by types from the Formative Period, also in very low frequencies (n=7; 1.1% of the sample). Among the Formative Period assemblage, fragments of the local Atacama Sequitor type (SEQ) and Tarapacá traditions were observed -Quillagua Rojo Pulido (QRP) and Quillagua Tarapacá Café Amarillento (QTC). Fragments that could not be assigned to a specific type were a significant part of the ceramic assemblage (n=28; 4.7% of the sample).

In terms of the spatial distribution of ceramics, all the types assigned to the Formative Period were recovered at the Residential Area 2, both found on the surface and in the upper layers of Unit 4 (Fig. 4), potentially marking the earliest occupation of the site in association with the radiocarbon date of Unit 9A. The specimens of the *Loa-San Pedro* component—exhibiting higher concentrations—were distributed around the site, on the surface as well as in stratigraphic deposits. Fragments from the Inca Period were recovered in both residential areas, and in the upper platform. Evidence of Inca Imperial vessels, on the other hand, were only found on the surface, while Inca Period local types (TPA and IND-MICA) were found in the upper levels of unit 9A, in association with *Loa-San Pedro* sherds.

Based on the ceramic assemblage and the radiocarbon dates, we infer a long occupation of the mine beginning in the Formative Period, with a clear intensification during the subsequent Late Intermediate Period as signaled by the presence of locally-made vessels for cooking and serving. The same style continued to be used during the Late Inca Period, but the introduction of Inca types indicates that El Cóndor was at this time part of a wider network of circulation controlled by *Tawantinsuyu*, a situation also observed in other mining sites of the region (Adán and Uribe, 2005; Núñez et al., 2003; Salazar, 2008; Salazar et al., 2013b). The infrequent presence of post-Hispanic ceramic vessels suggests that while the

site may have been in operation after the Spanish conquest, the occupation was less intense.

3.4. Exploitation and production sequences

Material evidence from the mine allows a characterization of the different stages of pigment production: extraction of ores followed by crushing *in situ*; transportation of the mineral to the processing platforms; crushing and grinding; and finally, the circulation of pigment outside of the mine for its subsequent consumption. The operation of the mine also involved transporting provisions to support the labor of people working and living at the site.

The three mining shafts present different morphological characteristics (irregular and regular borders, the latter possibly associated with more recent use), but they lack additional infrastructure (Fig. 3B). Three mineral veins with different textures, degrees of hardness, and color are present, varying from yellow to red. Along the edge of the largest shaft there are visible marks of a sharp instrument—possibly made of metal—that was employed to extract ores from the vein. Chronological details are difficult to infer, given that the tool used could have been a pre-Hispanic chisel, or a small post-contact pickaxe. Below the shaft, there is a large tailing that resulted from the process of extraction and crushing of mineral, as well as the natural movement of material down the hill (Fig. 3A). The excavation unit placed outside the main shaft did not yield diagnostic material but only fragments of minerals. Once the ores were extracted from the veins, smaller pieces were moved to the processing platforms following a steep path. The containers employed for their transportation were possibly knitted, as suggested by the different types of fibers and cords that were recovered from the excavation units, or made using animal skins or basketry—as documented at other sites (Bird, 1977-1978; Figueroa et al., 2013).

On the upper area (Processing Areas 1, 2, 3, 4, and 5), miners continued the reduction of pigment ores, through activities like crushing and grinding (Fig. 7). Unlike other mining contexts (Bird, 1977-1978; Figueroa et al., 2013), the process of reduction was carried out with unhafted hammerstones. Following the process of reduction, smaller pieces were placed on top of the flat surfaces of the ignimbrite blocks, which show multiple cavities used as mortars (“cupstones” or “anvil stones”). Miners picked fine-grained, soft, and highly colored fragments, as attested by the remains of red powder inside the mortars and on the pestles recovered on and around the boulders used for grinding (Figs. 7D-E). The raw material selected for making mortars and pestles was available in the immediate surroundings, and the process of grinding through light friction was facilitated by the soft texture of the stones employed, resulting in the production of a very fine and highly effective colorant powder (Figs. 7 and 11A). Other lithic tools probably used in mining activities are also observed around residential units (Figs. 11B-11D).

The absence of storage structures indicates that once the powder was produced, it was kept in portable containers and promptly transported to other locations. Seashells filled with pigments and wrapped in cloths have been found in funerary contexts at cemeteries along the middle Loa River, the Pacific coast, and other oases in the region (González and Westfall, 2010; Hermosilla and Barrera, 2010; Latcham, 1938; Núñez, 1984, 1991; Sarmiento and

Castillo, 2016; Téllez, 1997; Thomas et al., 1995), suggesting that this could have been one of the preferred ways to store and transport pigment (Fig. 12). This method was probably employed at El Cóndor, given the high frequency of mollusk valves. However, other types of containers could have been used for the same task, such as ceramic vessels, skin bags, or wooden boxes—all of which have been reported at other sites in the region (Boman, 1908; Crequi-Montfort, 1906; Latcham, 1910, 1938; Montell, 1926; Mostny, 1952; Núñez, 1964; Ryden, 1944; Spahni, 1967).

Based on the occupational sequences of each of the units excavated, we can infer that most of the processing activities took place outside the habitational structures, although some material could have been carried inside as a consequence of transit or wind transportation. Strata that reveal more intense processing are consistently located above the first domestic occupations, and tend to overlap with the later ones. In sum, the domestic deposits of Residential Area 2 indicate that the exploitation and processing of pigments began during the Formative Period, and increased during the LIP and Inca periods—when the site was expanded through the incorporation of another residential area (Residential Area 1).

4. Economic and political implications of the exploitation of El Cóndor Mine during the Late periods

El Cóndor mine was an important site in the Atacama Desert because the pigment that was produced here was widely distributed throughout the region, articulating different localities and individuals, while creating technological and symbolic networks of travel and trade. Pigments acquired social importance not just because particular forms of labor were necessary for its production, but also because they were employed in variable social contexts. Integrated into diverse technological spheres, pigment was employed as slip or paint for ceramic vessels, for the creation of rock art, and for decorating a variety of material objects. The high frequency of rock art sites through the Atacama Desert corroborates the importance of red paint in pre-Hispanic times, contributing to the creation and exchange of visual information among pre-historic peoples (Gallardo, 2009; Gallardo et al., 2012). Wooden posts with anthropomorphic figures painted in red found at Chacance and Chiu-Chiu (Gallardo and Mege, 2012; Núñez, 2002) suggest that pigment may have also been used as face paint (Fig. 13), and specific forms of decoration and color codes could have served as identity markers among individuals and groups. Consequently, the ubiquity and diversity in forms of consumption—different from the contexts of use and consumption of minerals and metals—speaks to its availability and its social significance. In this context, pigment miners must have had notable social, economic, and political roles.

The evidence found at El Cóndor reveals that the site combined different mining phases, including the extraction and production of pigments, following the categories proposed by Eerkens and collaborators (2009). In parallel, it incorporates housing infrastructure for the miners that permanently worked at the site. These are extremely unique characteristics for a settlement of this nature, given that the other two known iron oxide pigment mines in the Andean region—La Primavera (Vaughn et al., 2013a) and San Ramón 15 (Salazar et al., 2011, 2013a)—include either extraction and processing areas, or only extraction areas, respectively.

At El Cóndor, all the processing phases were carried out *in situ*, and the workers resided on site while they were exploiting the mine. The size and type of construction of the circular enclosures, in addition to the quantity and density of material remains recovered, indicate that these were short-term occupations. The products consumed at the site were not produced locally, but transported from other localities to sustain the population of mineworkers residing at El Cóndor. The absence of cemeteries provides additional evidence that confirms the transient use of this space. Similarities can be inferred with other mining sites in the region, such as Chuquicamata-2 (Núñez et al., 2003) or Cerro Turquesas (Salazar et al., 2010), which have been defined by ephemeral occupations comprised by logistical camps. In contrast, other pre-Hispanic mines in northern Chile, such as Mina de las Turquesas or Indio Muerto in San Salvador (Iribarren 1972-1973; González and Westfall, 2008; Kuzmanic and Sanhueza, 1984) include funerary areas adjacent to extractive and productive spaces, denoting long-term or more stable occupations.

Chronologically, the mine was in use from the Formative Period onwards, but most of the infrastructure that is currently visible dates to the Late Intermediate (LIP) and Late or Inca periods. Although most of the pottery recovered corresponds with diagnostic types from the LIP, these vessels continued to be used throughout the Inca Period (Uribe, 2004b), corroborating that the mine was more intensively exploited between the 14th and 16th centuries.

The existence of foreign objects reveals that since the onset of the occupation, people who worked at the mine maintained strong relations with other territories, such as Tarapacá, the Pacific coast, Chacance, and the Calama oasis—possibly the point of origin of the mineworkers. The circulation of pigment generated a long-lasting and intensive system of economic exchange (Gallardo et al., 2016; Labarca and Gallardo, 2012; Pestle et al., 2015; Torres-Rouff et al., 2012). During the Inca Period, the presence of imported pottery (Copiapó) as well as the ubiquity of fish remains substantiates the geographical expansion of these networks of exchange. Similarly, Inca pottery confirms the incorporation of the mine operation under some form of imperial control. A *tambo* located 11 km west of El Cóndor along the route that connected the oasis of Calama with Chacance, Quillagua, and the Pacific Ocean, provides further indication of the oversight exercised by the Inca over the circulation of this resource. However, given that pigment production began prior to the Inca expansion, occupation and control was surely based on pre-existing circuits of trade that were reconfigured and expanded by the state administration.

Long-distance circulation of pottery during Inca times can be associated to new forms of control, and present two possible scenarios concerning the distribution and circulation of goods: direct control over pigment production and circulation by the Inca administration; or exclusive control over circulation, which must have involved particular forms of negotiation with local mineworkers, who could have maintained the management of production. The appropriation of mining resources, metal production, and possibly lapidary production, has been consistently documented in different areas of the Atacama Desert, involving ritual and symbolic mechanisms that were put in place by the *Tawantinsuyu* empire (Cantarutti, 2013; Salazar et al., 2013b, 2013c). In pre-Hispanic mines of Tarapacá, El Abra in the upper Loa River), and Los Infieles in Coquimbo, the imperial administration transformed mining production by introducing highly specialized technological processes accompanied by the

spatial reorganization of the settlements (Cantarutti, 2013; Berenguer and Salazar, 2017; Núñez, 1999; Salazar et al., 2013b, 2013c; Uribe, 1999-2000; Zori et al., 2012). At El Cóndor, there is no evidence of Inca architecture suggesting direct control over the mine. However, the existence of rock art from this period (checkered figures), could be interpreted as a visual and symbolic appropriation of this space by the Inca state (Fig. 8) (Berenguer, 2013:342). The production of these diagnostic motives over previous rock art panels suggests that local populations could have been involved in ritual practices introduced by the imperial administration, aimed at resignifying spaces that had previous use. The introduction of new forms of negotiation and exchange between the Inca and local populations may have involved the creation of social events such as feasts (see Bray, 2003), where significant amounts of goods were served and consumed. Taking into account the presence of Inca plates and foreign resources, the possibility and importance of these kinds of ritual celebrations cannot be discarded.

Bernabé Cobo (1890) mentions that during the imperial expansion, the Inca controlled specific mines, while others were administered and exploited by the population of the provinces, saving part of the production as tribute to the state. The investment in infrastructure that is observed at El Cóndor mine during the Inca period, in addition to the process of intensification of production, indicates that there was the need to increase production for local consumption and possibly to meet new economic demands introduced by the state. Near the valley of Copiapó, Garrido (2015, 2016) reports the existence of a mine where the iron oxide was extracted from mineral outcrops, an activity carried out exclusively by local miners who possibly worked for the state under the *mita'* system (Murra, 1978). The mechanisms that controlled pigment production under Inca rule secured a continuous supply for the empire, while covering local demands through intensification of production. This phenomenon was materially manifested at El Cóndor, although the process of intensification did not radically transform workspaces or technologies, but rather maintained traditional forms of production. The Inca guaranteed a continuous supply of non-local goods, such as vessels and food, in exchange for tribute.

Ethnohistorical sources provide additional information for understanding the economic importance of pigments during Colonial times, illustrating the ways in which these industries were largely based on pre-Hispanic forms of production—most of which were institutionalized by the Inca state. Gold, silver, and copper mining were important activities and profitable industries for the Spanish Crown from the 17th century onwards (Platt and Quisbert, 2008). Many sources describe the significance of pigments in the colonial pictorial tradition of the Americas and Europe, where these new materials became sought after for local consumption (see Cobo, 1890; Guzmán et al., 2016; Seldes et al., 1999, 2002; Siracusano, 2005; Tomasini et al., 2012, 2016). Several accounts also refer to the process of extirpation of idolatries of local populations, who venerated mines as *huacas*, that is, sacred places or divinities (see Assoudrian, 1982; Bouysse-Cassagne, 2005, 2008; Platt and Quisbert, 2008; Saunders, 2004; Van Buren and Cohen, 2010; Van Buren and Weaver, 2012). These accounts provide descriptions of the location of sources, their traditional forms of exploitation, and the routes used for the circulation of minerals prior to the arrival of the Spaniards. In 1551, Spanish chronicler Juan de Betanzos mentioned that the mines of “colored powders” in Lípez region (Southern bolivian highland) were highly valued by the Inca, and that the products of those mines were claimed as tribute and subsequently

distributed through wide transregional networks of trade (Siracusano, 2005). Referring to the military campaigns of Tupac Inca Yupanqui, he states:

“vino a dar a una provincia que llaman Llipi en la cual provincia halló que la gente della era pobre en comidas y los mantenimientos della eran quinua tostada que es semilla blanca e muy menuda e algunas papas y los edificios eran cubiertos con unos palos fofos que son corazones de unas espinas de madera muy liviana y muy ruin y las casas pequeñas y bajas y gente muy ruin lo que estos tenían eran minas de muchos colores que nosotros tenemos y ansi mismo poseían algún tanto de ganado y ansi mismo en aquella tierra muchas avestruces y los naturales de los poblezuolos bebían de xagueyes y manantiales muy pequeños a estos mandó que le tributasen de aquellos colores y de aquellos ganados e ansi lo hicieron y partieron de allí por tierra muy estéril de aguas y comidas y por tierra rasa y sin monte y todo lo demás eran salitrales. [...]lo que estos tenían eran minas de muchos colores muy finas para pintar y de todos aquellos colores que nosotros tenemos [...] a estos [[indios]] mandó [[Tupac Inca Yupanqui]] que le tributasen de aquellos colores” (Betanzos [1551, cap. XXXVI] 1987: 164” (Betanzos [1551, cap. XXXVI] 1987: 164)².

The ethnohistoric references for the region of LÍpez, offer yet another valuable illustration of the mechanisms through which pigment production may have operated in the Atacama Desert (Betanzos, 1987). Furthermore, El Cóndor mine provides evidence that indicates that for the Inca Empire, the interest in the region was not solely based on the ubiquity and economic relevance of metallurgic resources, but that non-metallic mining was also an important economic activity (see Berenguer and Salazar, 2017; Núñez, 2006; Salazar et al., 2013b). These processes of exploitation and circulation characterized by a new form of negotiation continued during Historic Colonial times.

Conclusion

The evidence at El Cóndor mine indicates that the extraction and production of pigments was geared towards local and regional consumption from the Formative to the Late Intermediate Periods. In the Late or Inca Period, the construction of infrastructure, the extension of the network of roads, and the presence of foreign objects at the site, suggest that production increased and the sphere of circulation was significantly expanded. The absence of indications of direct control over the mines by the state implies that local miners had certain level of autonomy, and that their labor was highly valued by the empire.

El Cóndor mine constitutes an important example for understanding the social, historical, economic, and political implications of pigment production in the Atacama Desert. It contributes to documenting the lifecycle or the biography of hematite (Boivin, 2004; Jones and MacGregor, 2002; Kopytoff, 1991), and to follow the trajectories of its use and consumption. The versatility and social importance of red pigment indicates that it was a valuable resource to produce and exchange (Miller, 2006). This case could be compared to similar examples of pigment exploitation in other regions of the world in order to understand its role beyond the aesthetic dimension, as an element through which social relations were constructed and obligations between different entities were established.

Investigating the economic cycle of pigments can contribute to our understanding of economic and symbolic behaviors in ancient societies, taking into consideration technological dimensions that have often been overlooked by archaeological studies.

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FOOTNOTES

¹ The physico-chemical analysis will provide elemental and molecular characterizations of pigments. We employ PIXE-PIGE to determine the variability of the elemental make-up of the samples obtained at the site, specifically those extracted from the iron oxide vein. The elemental footprint will aid in establishing a baseline that will allow comparisons with samples across sites in the region. PIXE-PIGE analyses, combined with Portable X-Ray Fluorescence, will permit an elemental characterization of a large number of objects without the need to extract additional samples. This will allow a preliminary classification and help in determining provenance of the pigments used on different objects. In order to evaluate mineralogical variability, RAMAN spectroscopy and X-Ray diffraction will be used on different colors and tone samples obtained from different areas of extraction and processing. In the future we do not rule out combining these results with isotope analysis.

² “He arrived to a province called *Llipi*, in which province he found that people were poor in food and that their maintenance was toasted quinoa which is a white seed and often some potatoes, and the buildings were covered with flabby sticks with wood spines very lightweight and bad, the houses were smalls and low-rise, and the people had mines of several colors that we have and also they had some cattle and in the same land a lot of ostrich, and the naturals from small farms drunk from *xagueyes* and small springs, who he send to tribute with these colors and cattle, and they dit it, and they started from there by lands lacking of water and food, by flat lands and without mounts, and all the rest was saltpeter. [...] What they had was mines of many colors, very fines to paint and of all the colors that we have [...] to these Indians [Tupap Inca Yupanqui] send to tribute to him with these colors”.

FIGURE AND TABLE CAPTIONS

FIGURES

Figure 1: Map of the sites and areas mentioned in the text, including the location of El Cóndor mine.

Figure 2: Location of the mine and the different areas of the site.

Figure 3: Mining shafts located on the slope of the Loa River valley: (A) Detail of the mining waste or tailing; (B) Detail of the access to the main shaft.

Figure 4: Profiles and plan drawing of El Cóndor: (A) Profile section including platforms, residential, and processing areas; (B) Plan drawing showing the spatial distribution of the areas of the site.

Figure 5: General view from the upper platform.

Figure 6: Drawing of the habitational structures and processing areas: (A) Residential Area 1; (B) Residential Area 2; (C) Processing Area 3. Pestles are indicated in red.

Figure 7: Details processing areas: (A) Processing Areas 1, 2, and 3 with Residential Area 2; (B-C) Processing Area 2; (E-F) Processing Area 3.

Figure 8: Rock art paintings located in the upper platform: (A) General view; (B) Detail of the panel, with checkered figures (image processed with PydRA, by Enrique Cerrilo-Cuenca).

Figure 9: Stratigraphy of the excavation units: (A) Unit 8, Residential Area 1; (B) Unit 9; Residential Area 2 (Sup: Superficial layer).

Figure 10: Diagnostic ceramic fragments recovered from surface collections and excavations: (A-B) CNSR type, with geometric designs and camelids (Surface, Unit 6, Residential Area 1); (C) CNSR type (Surface, Unit 7, Residential Area 1); (D) Fragment of jar, Foreign Inca (INK) type with black lines over white (Surface collection, Residential Area 2); (E) Fragment of a QRP cup (Layer 1, Unit 4; Residential Area 2); (F) Fragment of handle (Surface collection, Residential Area 2).

Figure 11: Lithic assemblage: (A) Pestle or *mano* (Processing Area 1); (B) Lithic tool (Residential Area 1); (C) Lithic tool using a flake, possibly used for mineral extraction (Mining waste); (D) Lithic tool using a flake (Layer 6, Unit 8, Residential Area 1).

Figure 12: Pigment containers using mollusk valves: (A) Container with red pigment using a valve of *Strophocheilus oblongus*, El Vertedero Municipal de Antofagasta, Pacific coast (Carrasco et al., 2015); (B-C-D) Red pigment containers using valves of *Concholepas concholepas*, Topater 01, Calama (Sarmiento and Castillo, 2016).

Figure 13: Wooden posts with anthropomorphic figures found in the region: (A) Post found as a grave good in burial 5 of Chacance 01 (Núñez, 2002); (B) Drawing of a similar post recorded by Junius Bird in the 1940's (85 cm tall and 19 cm of diameter), Chiuchiu archaeological collection (taken from Junius Bird's field notes at the American Museum of Natural History, New York City); (C) Detail of the facial decoration of the anthropomorphic figure reported by Bird.

TABLES

Table 1: Radiocarbon dates from El Cóndor mine. Calibrated using Calib 7.0 (Stuiver et al., 2005), with curve SHCal 13 (Hogg et al., 2013).

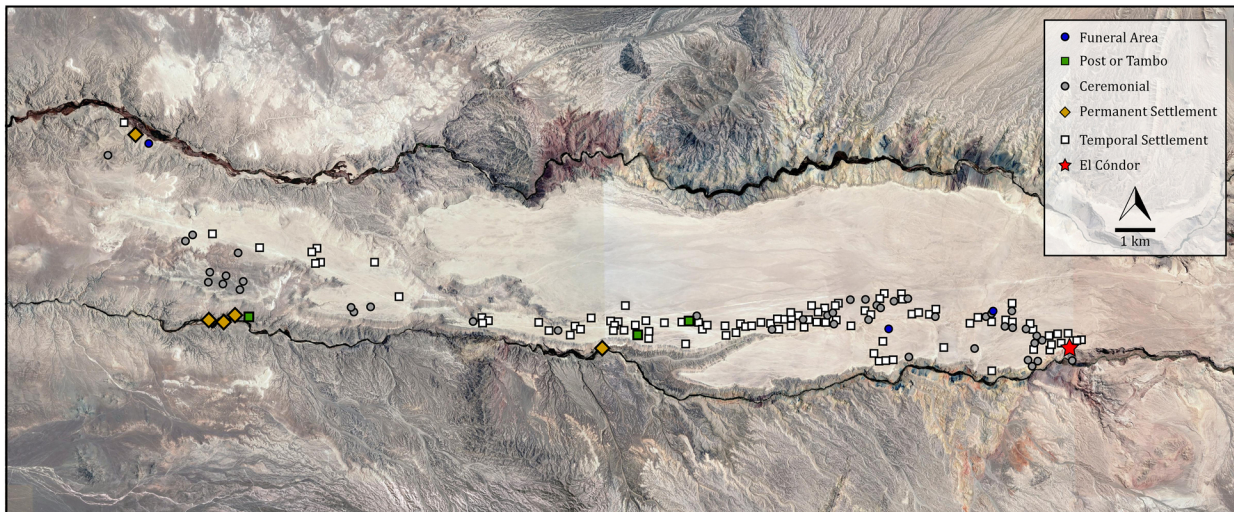
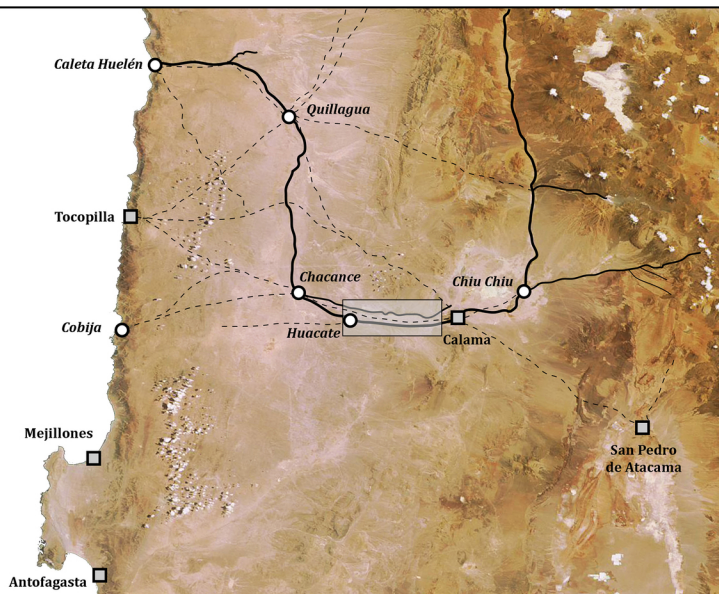
Table 2: Ceramic material recovered from surface and excavated units.

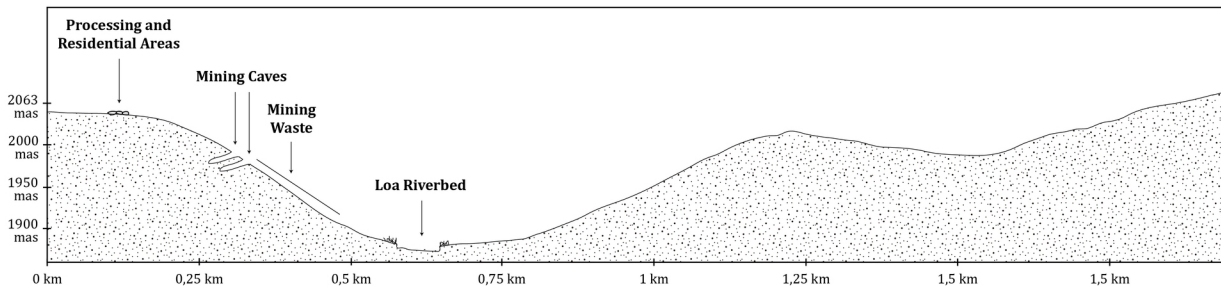
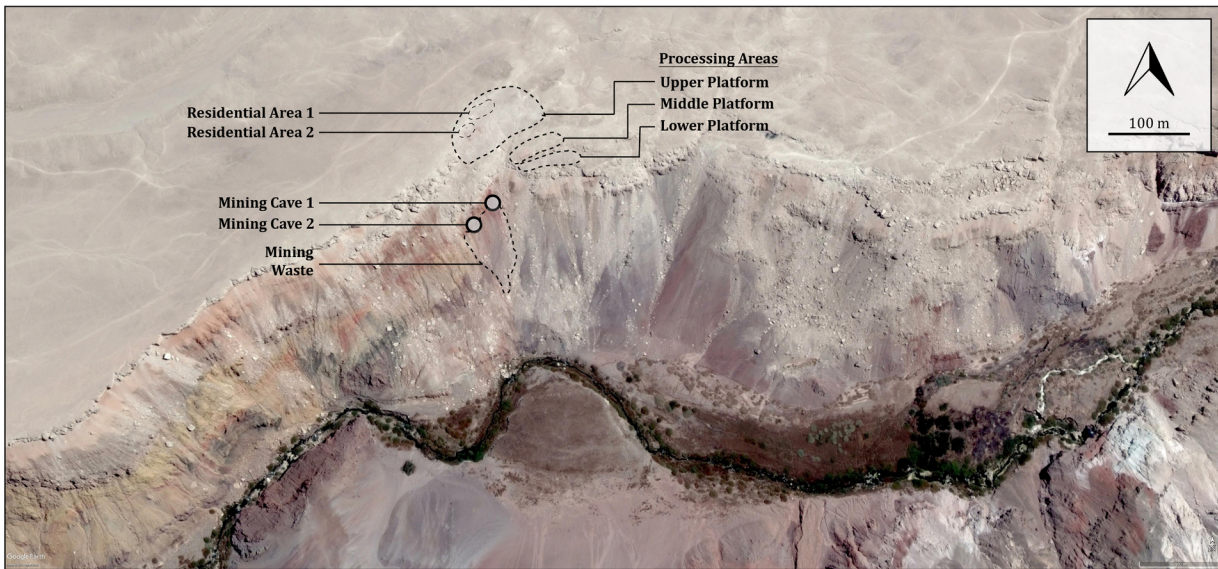
Table 1

Sample code	Context	Material	Datation ¹⁴ C (BP)	¹³ C/ ¹² C (o/oo)	Calibrated datation (AD) +/- 2 sigma
BETA-342983	Unit 9, Layer 4	Charcoal	1670+/-30	-23.3	365-523
BETA-342982	Units 8-8A, Layer 6	Charcoal	800+/-30	-22.8	1.220-1.290
BETA-342981	Units 8-8A, Layer 5	Charcoal	600+/-30	-23.5	1.385-1.432

Table 2

Chronology	Ceramic Type	Form	Selective collection	Excavation	Total
Atacama Middle to Late Formative	SEQ	bowls/dishes, vase-cups	1	1	2
Tarapacá Late Formative	QTC	bowls/dishes, vase-cups, pots/pans	4	0	4
	QRP	cups, bottles	0	1	1
Loa-San Pedro de Atacama Late Intermediate Period	TRA	jugs, bowls/dishes	40	132	172
	TGA	pots/pans, vessels	47	88	135
	TRR	jugs, bowls/dishes	7	4	11
	SRV	jugs, bowls/dishes	0	2	2
	AIQ	bowls/dishes	91	51	142
	DUP	bowls/dishes	5	27	32
	TRP	bowls/dishes	14	6	20
Tarapacá & Atacama Late Period, Inca-Local	TPA	shallow dishes	3	6	9
	LCE	inka jars (aríbalos)	1	2	3
Inca Imperial	INK	jars, bottles, bowls/dishes	5	0	5
Inca Foreigner	CNSR	bowls/dishes	0	3	3
Inca-Historic Colonial Transition	IND-MICA	pots/pans, vessels	0	16	16
Historic	HIS	vessels	2	0	2
Indeterminate	ERO		0	21	21
	IND		1	6	7







Upper Platform

Residential Area 1
Residential Area 2
Processing Areas 1, 2 & 3

Middle Platform

Processing Area 4

Lower Platform

Processing Area 5

5 m

A

Residential Area 1

Residential Area 2

Processing Areas 1, 2 & 3

Rock Art

Mining Caves

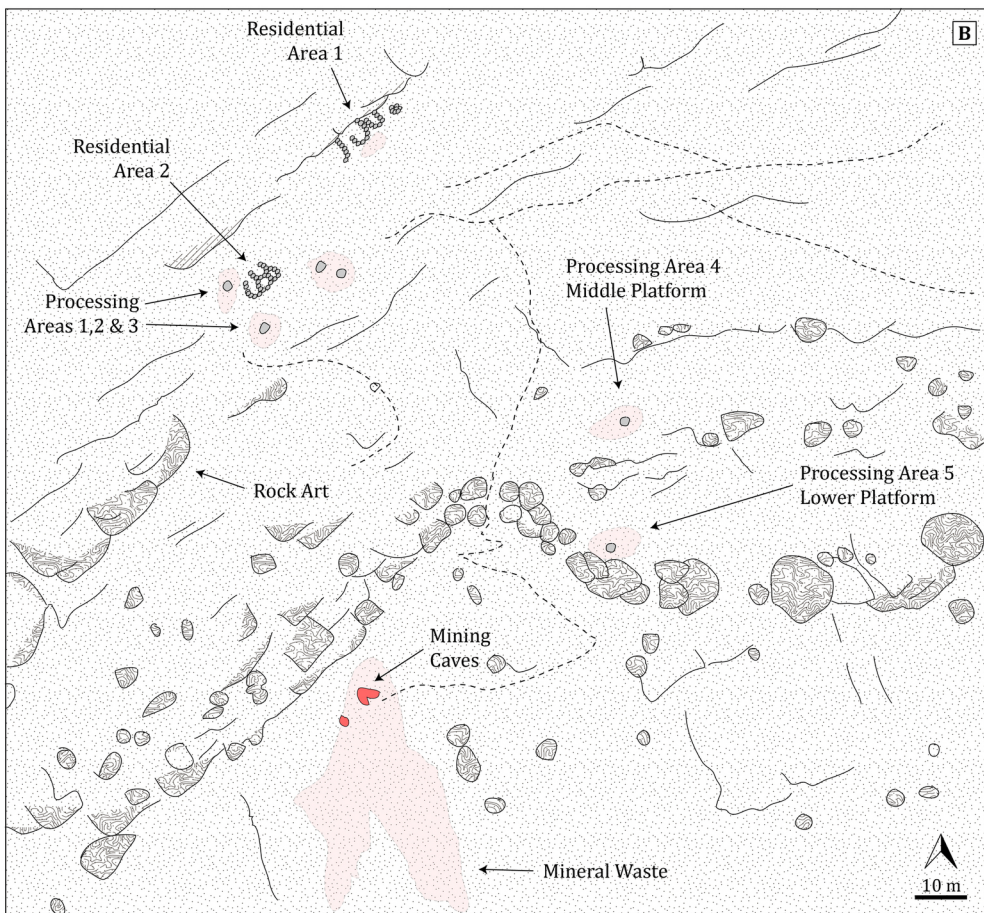
Processing Area 4
Middle Platform

Processing Area 5
Lower Platform

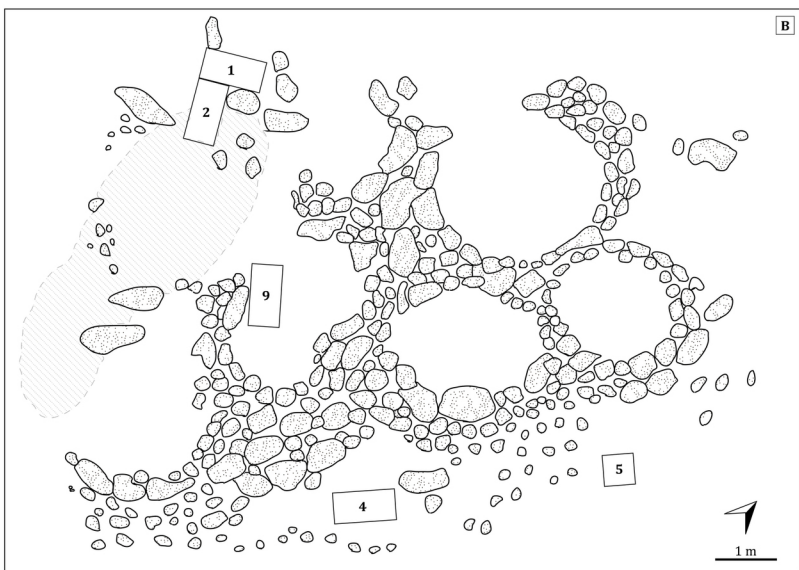
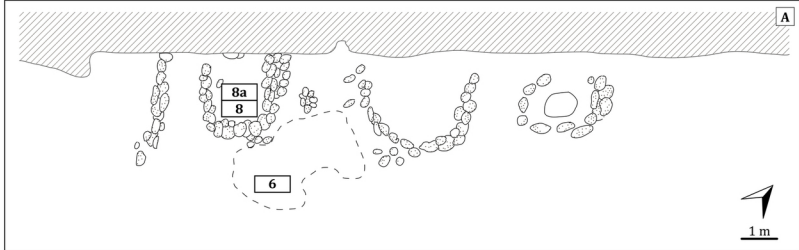
Mineral Waste

10 m

B



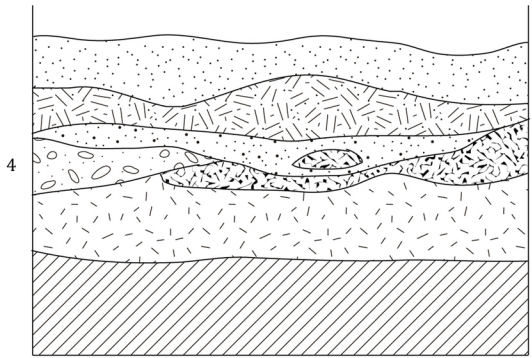




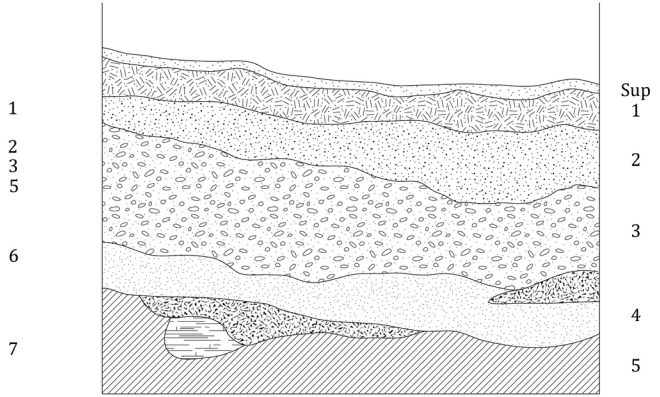




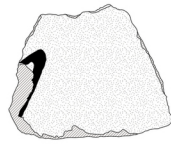
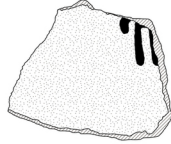
A
10 cm



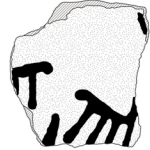
B
10 cm



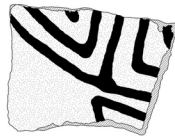
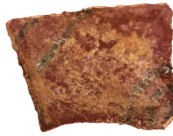
A



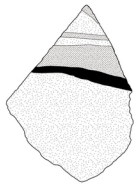
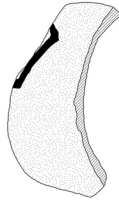
B



C



D



E



F



A



B



C



D



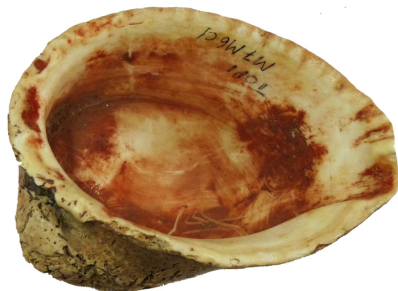
A



B



C

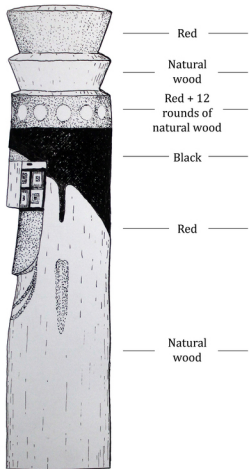


D

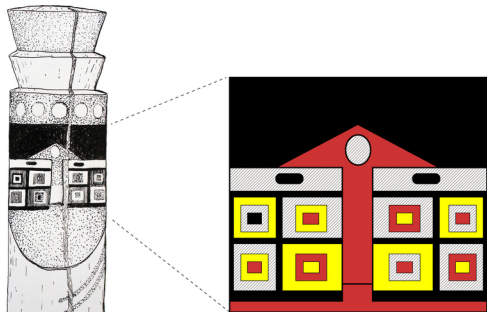




A



B



C