



FROM THE PACIFIC TO THE TROPICAL FORESTS: NETWORKS OF SOCIAL INTERACTION IN THE ATACAMA DESERT, LATE IN THE PLEISTOCENE¹

DESDE EL PACÍFICO A LA FORESTA TROPICAL: REDES DE INTERACCIÓN SOCIAL EN EL DESIERTO DE ATACAMA DURANTE EL PLEISTOCENO FINAL

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The social groups that initially inhabited the hyper arid core of the Atacama Desert of northern Chile during the late Pleistocene integrated a wide range of local, regional and supra regional goods and ideas for their social reproduction as suggested by the archaeological evidence contained in several open camps in Pampa del Tamarugal (PdT). Local resources for maintaining their every-day life, included stone raw material, wood, plant and animal fibers, game, and fresh water acquired within a radius of ~30 km (ca. 1-2 days journey). At a regional scale, some goods were introduced from the Pacific coast (60-80 km to the west, ca. 3-4 days journey), including elongated rounded cobbles used as hammer stones in lithic production, and shells, especially from non-edible species of mollusks. From the Andes (ranging 80-150 km to the east, ca. 5-8 days of journey), they obtained camelid fiber, obsidian and a high-quality chalcedony, in addition to sharing knowledge on projectile point designs (Patapatane and Tuina type forms). Pieces of wood of a tropical forest tree species (*Ceiba* spp.) from the east Andean lowlands (600 km away, ca. 30 days of journey) were also brought to the PdT. While local goods were procured by the circulation of people within the PdT, the small number of foreign items would have been acquired through some sort of exchange networks that integrated dispersed local communities throughout several ecosystems. These networks may have been a key factor behind the success exhibited by these early hunter-gatherers in the hyper arid ecosystems of the Atacama Desert at the end of the Pleistocene.

Different lines of archaeological evidence including open camps, workshop-quarries, lithic artifacts, archaeofaunal remains, plant and animal fibers and textiles, archaeobotanical remains, and paleoecological data show that people of the PdT managed a wide range of cultural items from the Pacific coast, the Andean highland and the tropical forest, that were integrated with resources

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gathered locally within the socio-cultural systems established by the end of the Pleistocene. These results are interpreted as material expressions of multi-scalar networking for resource management and other social material and immaterial requirements, which in other words, means that these people were actively connected to regional (coastal and highland), and supra-regional (trans-Andean) exchange networks from and out of the PdT.

Key words: Local, regional and pan-Andean networks of interaction, Atacama Desert, Pacific coast, Andes, tropical forest.

Los grupos sociales que inicialmente habitaban el núcleo hiperárido del Desierto de Atacama en el norte de Chile durante el Pleistoceno tardío integraron una amplia gama de bienes e ideas, locales, regionales y supra regionales, para su reproducción social, como lo sugieren las evidencias arqueológicas materiales recuperadas en varios campamentos al aire libre en Pampa del Tamarugal (PdT). Los recursos locales para mantener su vida diaria, incluían materias primas líticas, fibras de plantas y animales, presas de caza y agua dulce adquiridos en un radio de ~30 km (ca. 1-2 días de viaje). A escala regional, se introdujeron algunos elementos desde la costa del Pacífico (60-80 km hacia el oeste, ca. 3 a 4 días de viaje), incluidos rodados redondeados alargados, utilizados como percutores en la producción lítica y conchas, especialmente de especies no comestibles de moluscos. Desde los Andes (80-150 km al este, ca. 5-8 días de viaje), obtuvieron fibra de camélido, obsidiana y una calcedonia de alta calidad, además de compartir conocimientos sobre diseños de puntas de proyectil (tipo Patapatane y Tuina). También se llevaron a la PdT trozos de madera de una especie de árbol de los bosques tropicales (Ceiba spp.) de las tierras bajas al este de los Andes (600 km de distancia, ca. 30 días de viaje). Mientras que los bienes locales fueron adquiridos por la circulación de personas dentro de la PdT, el pequeño número de artículos foráneos se adquirieron a través de redes de intercambio que integraron comunidades locales dispersas en varios ecosistemas; lo que debió ser un factor clave detrás del éxito demostrado por estos primeros cazadores-recolectores en los ecosistemas hiperáridos del Desierto de Atacama hacia el final del Pleistoceno.

Diferentes líneas de evidencia arqueológica que incluyen campamentos al aire libre, talleres, canteras, artefactos líticos, restos arqueofaunales, fibras y textiles de plantas y animales, restos arqueobotánicos y datos paleoecológicos, muestran que la gente de la PdT manejaron una amplia gama de elementos culturales desde la costa del Pacífico, el altiplano andino y el bosque tropical, que se integraron a los recursos recolectados localmente dentro de los sistemas socioculturales establecidos al final del Pleistoceno. Estos resultados se interpretan como una expresión material de una red de múltiples escalas para la gestión de recursos y otros requisitos sociales e inmateriales, lo que en otras palabras, significaría que estos grupos sociales estaban conectados activamente con redes de interacción regionales (costa y tierras altas) y supra-regionales (transandinas) desde y hacia la PdT.

Palabras claves: redes de interacción locales, regionales y pan-andinas, Desierto de Atacama, Costa del Pacífico, Andes, bosque tropical.

For scattered populations of hunter-gatherers, the need and the ability to maintain networks of social interaction is crucial to assure access to both utilitarian and non-utilitarian goods and to gather survival information, especially during times of shortage (Dillehay 2013; Veth 2008; Whallon 2006). Here we attempt to show that the hunter-gatherer societies that initially inhabited the Pampa del Tamarugal (PdT) basin, an intermediate depression between the Pacific coast and the Andes (Figure 1) in the hyper arid core of the Atacama Desert, needed to develop and maintain extensive mechanisms for the transference of non-utilitarian and utilitarian goods (found in the archaeological record) as well as partners and information, which in turn allowed them to create social networks, essential for the sustainability of their socio-cultural systems within hyper arid environments by the end of the Pleistocene. Hence, people that initially settled within the Atacama Desert, albeit likely at low population densities, should have developed strong and dynamic social networks at local, regional and supra-regional scales.

Unlike highly institutionalized later Andean circulation (e.g., Dillehay 2013; Dillehay and Núñez

1988; Núñez and Nielsen 2011; Salomon 1985), the transference of items and movement of people among late Pleistocene hunter-gatherer societies could have been operated under less structured systems. Particularly, the transport of low-frequency items may have occurred by means of several mechanisms of both direct and indirect acquisition. Direct mechanisms may include: the incidental acquisition of goods fixed in circuit of residential and logistic mobility (Binford 1979), for instance through transhumance (Dillehay 2013; Lynch 1971); as well as non-utilitarian mobility by long- and short-distance special-purpose trips (Gould and Saggars 1985; Grove 2014; Lovis et al. 2005; Newlander 2012; Pearce 2014; Speth et al. 2013; Whallon 2006). Indirect mechanisms may included: direct and indirect (down-the-line) economic exchange of utilitarian and non-utilitarian items (Dillehay 2013; Laguens et al. 2007; McBryde 1984; Mulvaney 2002; Silveira et al. 2010; Tripcevich 2010; Veth 2008; Wiessner 2002; Wilkins et al. 2010); flux of resources as part of marriages (bride price/service) (Walker et al. 2011); and incidental deposition of allochthonous goods as a result of visits and other sporadic and non-systematic activities (e.g., Gusinde

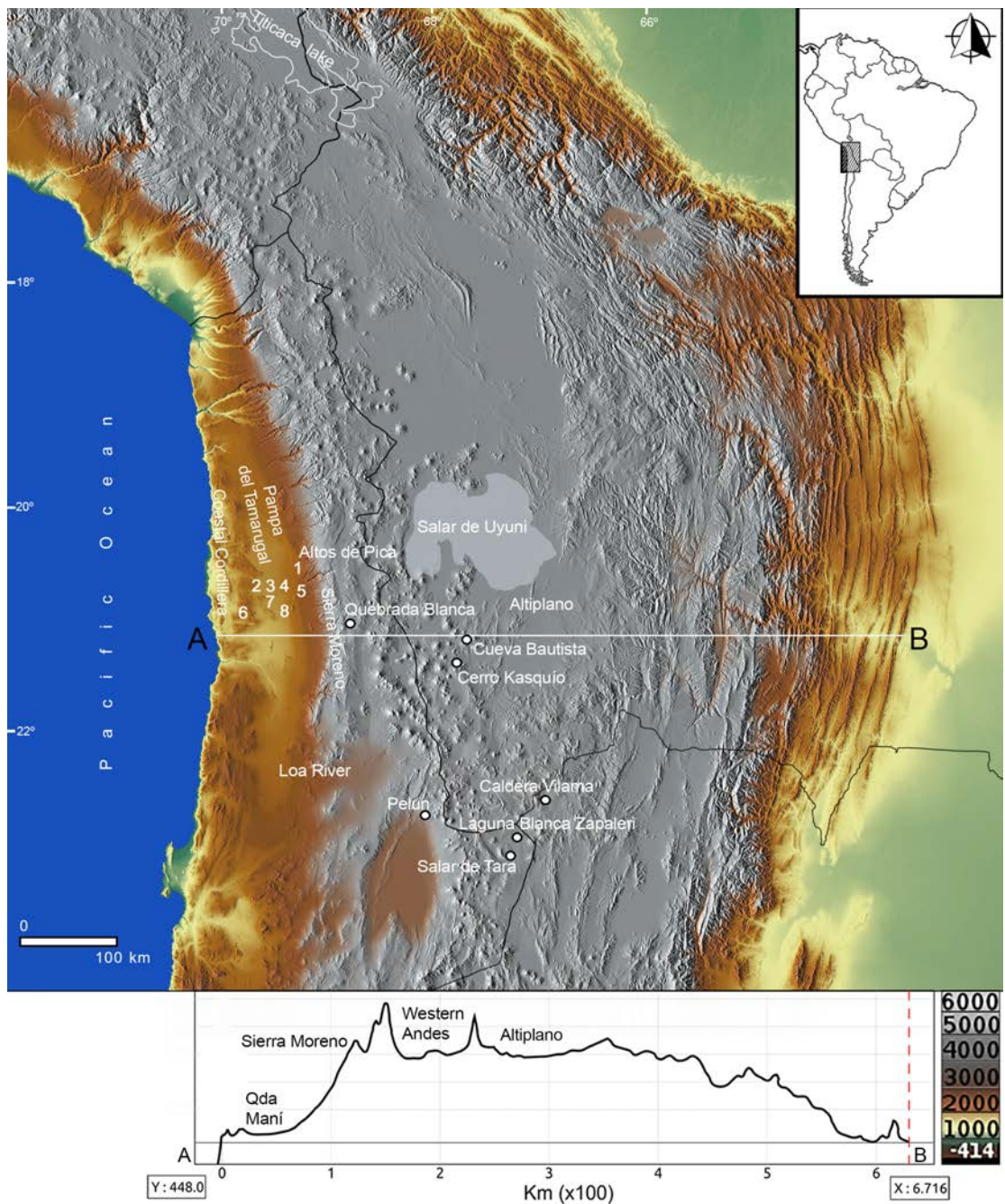


Figure 1. Late Pleistocene open camps distribution in Pampa del Tamarugal basin, in the core of the Atacama Desert (after Herrera 2017): (1) Quebrada Chipana (Chipana-1); Quebrada Guatacondo: (2) Pampa Ramaditas-4 (PR4), (3) Pampa Ramaditas-5 (PR5), (4) Pampa Ramaditas-7 (PR7); Quebrada Maní: (5) Quebrada Maní 12 (QM12), (6) Salar de Llamara 17 (SL17); (7) Quebrada Maní 35 (QM35), and (8) Quebrada Maní 32 (QM32).

Distribución de campamentos abiertos del Pleistoceno Tardío en la cuenca Pampa del Tamarugal, en el núcleo del Desierto de Atacama (tomado de Herrera 2017): (1) Quebrada Chipana (Chipana-1); Quebrada Guatacondo: (2) Pampa Ramaditas-4 (PR4), (3) Pampa Ramaditas-5 (PR5), (4) Pampa Ramaditas-7 (PR7); Quebrada Maní: (5) Quebrada Maní 12 (QM12), (6) Salar de Llamara 17 (SL17); (7) Quebrada Maní 35 (QM35) y (8) Quebrada Maní 32 (QM32).

1991 [1974]:130-134; Méndez et al. 2017; Pallo and Borrero 2015).

All of these mechanisms imply social interaction and the setting of social networks, which in turn allowed the procurement of exotic goods of prestige and sacred importance, but also expanding kinship and socio-politic relationships and getting ecological, geographical, and social information for “insurance purposes” (Grove 2014:3573), all of which have evolutionary advantages for social and biological reproduction (Cummings 2014; Dalton 1977; Gamble 1982; Gamble 1999; Gould and Saggars 1985; Hamilton et al. 2007; Newlander 2012; Pearce 2014; Politis 1996; Speth et al. 2013; Whallon 2006). The initial bands of hunter-gatherers (possibly ca. 25 people), such as those who initially explored the open landscapes of the PdT, required to constantly move and eventually join other groups to avoid extinction (Kelly 1995; Tolan-Smith 2003). Several small interconnected groups moving separately over a large territory increase the likelihood that they can learn more about a region and later share this knowledge, which would clearly improve their survival and adaptation capacities (Kelly 1995, 2003; Pearce 2014). Societies subject to extreme insecurities of key resources such as water, like those that inhabited the hyper arid ecosystems of the Atacama Desert, were more dependent on long-distance social networks (Gould and Saggars 1985:122).

The problem is the difficulty to identify and distinguish archaeologically direct and indirect mechanisms of acquisition / transfer of goods (Close 2000; Costin 2001). Although the presence of exotic goods in hunter-gatherer contexts is often explained by mobility, there is an increasing archaeological, ethnographic and ethnohistorical recognition that hunter-gatherers practiced various forms of exchange (Bate 1986; Cummings 2014; Dalton 1977; Delage 2018; Dillehay 2013; Gusinde 1991; Jordan 2014; McBryde 1984; Standen et al. 2018; Veth 2008). Our objective is not to discriminate the type of specific mechanism of acquisition / transference of goods that operated among late Pleistocene PdT hunter-gatherers because the availability of material is limited. Rather, based on ongoing interdisciplinary studies that integrated the available archaeological, isotopic and paleoecological data, we attempt to show the different geographical scales in which the networks of interactions functioned within these societies. We propose three kinds of network for resource management and other social material and immaterial requirements: local, regional and supra-regional scales. We aim to reconstruct and discuss how people integrated vastly different

territories and eventually built dynamic socio-cultural interaction networks in the Atacama Desert during the late Pleistocene.

The Pampa del Tamarugal

The Atacama Desert expands across the western flank of the Andes, extending from southern Peru to the Copiapó valley (~17°-27° S). Across these >1,400 km, the relief rises from the Pacific coast to the high-elevation Altiplano, and is accompanied by an abrupt elevation-precipitation gradient with widespread hyper aridity across the coast and low-elevation areas (0-2,000 masl), arid climates prevail along the pre-Andean cordillera (2,000-4,000 masl), with semi-arid but cold conditions over the Altiplano (>3,500 masl).

The PdT is a multi-aquifer system of more than 4,000 km² that lies within the central valley in the hyper arid core of the Atacama Desert. Here, the extreme negative hydrological balance leads to a landscape that is practically devoid of biotic and water resources. Nevertheless, the localized discharge of surficial and groundwater resources generates discrete oases for life. In fact, within deeply incised valleys (or *quebradas*) that drain the precordillera are dense riparian ecosystems that occur alongside perennial/ephemeral streams (Gajardo 1994; Luebert and Plissock 2006; Villagrán et al. 1999). Typically, these ecosystems in the northern Atacama (17°-21° S) incorporate endemic and native herbaceous and woody taxa such as *Escallonia angustifolia*, *Baccharis* spp., *Morella pavonis* (syn. *Myrica pavonis*), and *Schinus molle*, among others. Except for a few rodents, lizards, birds and amphibious species, the native faunal assemblage in these formations is limited (Marquet et al. 1998). Within the central valley, the localized evaporation and outcropping from shallow groundwater table maintains salt pans (*salares*) along the western margin of the PDT with phreato-halophytic vegetation consisting of *Prosopis* trees (*P. tamarugo* and *P. alba*), shrubs (*Tessaria absinthioides*) and herbaceous taxa (i.e., *Distichlis spicata*, *Atriplex atacamensis*) (Briner 1985; Luebert and Plissock 2006).

Paleoecological reconstructions for the ecological and hydrological setting of our study area show that during the Pleistocene-Holocene transition (13,000–9,000 cal yr BP) the hyper arid core of the Atacama Desert was a hospitable environment for humans. During this period, the PdT contained key resources (fresh water, plants, and game, plus good quality lithic raw materials) for the settling of small groups of hunter-gatherers that centered their life within this ecosystem. The PdT may have served also as an ecological corridor

connecting five different ecosystems on the western Andean slope: (a) the Pacific coast and Cordillera de la Costa 60-80 km to the west of the PdT, (b) the *quebradas* that drain the Andes 60-70 km to the east, (c) the Altiplano in the high Andes 80-150 km to the east, (d) the exoreic valleys to the north, and (e) the Loa River and the Salar de Atacama basin towards the south. Ecosystems between the Pacific coast and the tropical forests were more continuous than today, facilitating a long distance network of interaction and making transcontinental movement less difficult, both of which were crucial during this epoch of very low population density (Gayo et al. 2015).

Indeed, late Pleistocene human occupations of the PdT coincided in large part with a boom in local ecosystem productivity that arose from wetter conditions over the Andes (Gayo et al. 2012; Nester et al. 2007; Pfeiffer et al. 2018). These conditions occurred during the second stage of the Central Andean Pluvial Event (CAPE II; 13,000 - 9,800 cal yr BP, (Gayo et al. 2012), in which amplified precipitation in the high Andes induced significant positive hydrological budgets within the hyper arid core of the Atacama between 18° and 25°S (Gayo et al. 2012; Nester et al. 2007; Sáez et al. 2016). As a result, excess runoff from the highlands produced fertile green oases with abundant biotic resources along the low-elevation desert (Gayo et al. 2012; Nester et al. 2007). The associated archaeological sites we have studied were synchronous with CAPE II, although paleoclimate data suggest equivalent paleoecological and hydroclimatic conditions during the first CAPE stage (17,500–14,200 cal yr BP) yet no archaeology date to this period has been identified. Anomalous earlier and later dates of marine shell, wood, and plant remains are not considered within this time frame because of the marine reservoir effect and the presence of old – subfossil- wood (Table 1; Herrera 2017; Joly et al. 2017; Latorre et al. 2013).

Networks of Interaction

The archaeological evidence summarized below is presented to discuss multi-scalar networking practiced by hunter-gatherers occupying the PdT during the end of the Pleistocene, which we tentatively define as **local** (within the PdT), **regional** (coastal and highland), and **supra-regional** (trans-Andean) networks of interaction. Archaeological data come from one quarry (Cerro Chipana) linked to a workshop open camp in Quebrada Chipana (Chipana-1), and several open camps, all of which have been excavated and well-dated at the distal

section of the alluvial fans of Quebrada Guatacondo: Pampa Ramaditas-4 (PR4), Pampa Ramaditas-5 (PR5), Pampa Ramaditas-7 (PR7), and Quebrada Maní: Quebrada Maní 12 (QM12), Quebrada Maní 32 (QM32), Quebrada Maní 35 (QM35), and Salar de Llamara 17 (SL17). Forty-eight AMS dates have been obtained from these sites, excluding the last two sites (not yet dated), and these fluctuate between 12,420 to 9370 cal yr BP. These sites show that these people were well-adapted to the Atacama Desert as they contain abundant stone tools of different local and extra-local raw material and technology, processed plant and animal fibers, modified sea shells, and faunal remains associated, in some cases, with hearths and other features.

Local network

The local network corresponds to a social space that has been archaeologically identified within the southern section of the PdT circumscribed between the mouth and proximal section of the fan of the *quebradas* that drain into the eastern margin of this basin, and their distal section. Within a radius of 15 to 20 km we have inventoried five large archaeological areas: (1) the proximal section of the alluvial fan of Quebrada Maní (QM), (2) the distal section of the alluvial fan of the same quebrada and the canyon to the north - Pintados, (3) the distal alluvial fan section section of Quebrada Guatacondo known as Pampa Ramaditas (PR), (4) the quarry and work shop of Quebrada and Cerro Chipana (Chi) and (5) Salar de Llamara (SL), all of them covered with open camps numbered as QM12, QM32, QM35 PR4, PR5, PR7, Chi-1, and SL17, (Figure 1). The camps were part of a complex socioeconomic mobility system that took advantage of local resources generated by the and contemporaneous paleowetland and riparian ecosystems where the sites used to be located, which were available in the PdT during CAPE II (Boyd and Richerson 2005; Santoro et al. 2017).

The hunter-gatherers who inhabited these sites manifested technical knowledge and a concomitant socio-economic and technological organization, which included a wide range of lithic reduction techniques encompassing both simple and highly complex attributes, and the management of locally available resources, listed below:

(a) *Lithic raw material*

Silicified fine-grained cherts, fine-grained sedimentary dark rocks (lutites), and quartzitic sandstone

Table 1. Compilation of 48 AMS dates from five archeological site areas defined at Pampa del Tamarugal (PdT). *Recopilación de 48 fechas AMS obtenidas en cinco áreas con sitios arqueológicos en la Pampa del Tamarugal (PdT).*

Site	Unit	Sample ID	Material	¹⁴ C age	SD	Age cal yr BP*	Reference
Chipana 1	Test pit 3, E1B	UCIAMS 126285	Plant material	8390	25	9370	Herrera 2017
Chipana 1	Test pit 5, surface	UCIAMS 146016	Marine shell	8835	30	9045	Herrera 2017
Chipana 1	Test pit 5, surface	UCIAMS 146015	Marine shell	8860	35	9090	This study
Quebrada Maní 32	S88W45 level 3	UCIAMS134394	Plant material	9290	510	10500	This study
Chipana 1	Test pit 5, E2	UCIAMS 145144	Charcoal	9965	30	11310	Herrera 2017
Chipana 1	Test pit 5, E3	UCIAMS 145142	Charcoal	9970	35	11320	Herrera 2017
Chipana 1	Test pit 5, E1	UCIAMS 145139	Charcoal	9975	30	11320	Herrera 2017
Chipana 1	Test pit 5, E4	UCIAMS 145146	Charcoal	9995	30	11355	Herrera 2017
Chipana 1	Test pit 5, E1	UCIAMS 145140	Charcoal	10005	30	11370	Herrera 2017
Quebrada Maní 32	S1E8 ñivel 1B	UCIAMS 134397	Plant material	10005	45	11390	This study
Chipana 1	Test pit 5, E3	UCIAMS 145143	Charcoal	10010	30	11380	Herrera 2017
Pampa Ramadita 7	Test pit 1/1A-R2	UCIAMS 165644	Plant material	10010	80	11450	This study
Chipana 1	Test pit 5, E1	UCIAMS 145141	Charcoal	10020	30	11410	Herrera 2017
Quebrada Maní 32	S1E8 2B/feature 2	UCIAMS 134418	Plant material, cordage (acid only)	10040	35	11470	This study
Chipana 1	Test pit 5, E4	UCIAMS 145145	Charcoal	10045	30	11470	Herrera 2017
Chipana 1	Test pit 5, E1	UCIAMS 145138	Charcoal	10080	35	11535	Herrera 2017
Quebrada Maní 12	Stratum 2	UCIAMS 89015	Plant material	10080	25	11530	Latorre et al. 2013
Quebrada Maní 32	S1E8 level 1	UCIAMS 134396	Plant material	10085	35	11540	This study
Pampa Ramadita 7	Test pit 1/1A-R1	UCIAMS 165643	Plant material	10105	30	11600	This study
Quebrada Maní 32	S1E8 2B/feature 2	UCIAMS134417	Rodent pellet (acid only)	10115	35	11620	This study
Quebrada Maní 12	Stratum 3	UCIAMS 89020	Plant material	10120	25	11640	Latorre et al. 2013
Quebrada Maní 12	Stratum 4	UGAMS 8241	Wood	10130	30	11660	Latorre et al. 2013
Quebrada Maní 12	Stratum 4	UCIAMS 89017	Plant material	10160	25	11740	Latorre et al. 2013
Quebrada Maní 12	Stratum 4	UCIAMS 89021	Plant material	10165	25	11750	Latorre et al. 2013
Quebrada Maní 32	S1E8 level 2B/feature 2	UCIAMS 134399	Plant material	10180	40	11780	This study
Quebrada Maní 32	S1E8 level 1	UCIAMS 134406	Charcoal	10195	35	11820	This study
Quebrada Maní 32	S1E8 level 1	UCIAMS 134402	Charcoal	10205	35	11840	This study
Quebrada Maní 12	Stratum 5	UGAMS 7050	Charcoal	10210	30	11850	Latorre et al. 2013
Quebrada Maní 32	S1E8 level 2B	UCIAMS134398	Plant material	10210	35	11850	This study
Quebrada Maní 32	S1E8 level 2B	UCIAMS 134405	Charcoal	10210	45	11840	This study
Quebrada Maní 32	S1E8 level 1B	UCIAMS134404	Charcoal	10215	45	11850	This study
Quebrada Maní 12	Stratum 4 base	UGAMS 8242	Wood	10220	30	11870	This study
Quebrada Maní 32	S1E8 level 1	UCIAMS 134403	Charcoal	10220	40	11860	This study
Quebrada Maní 12	Stratum 4 base	UGAMS 8243	Wood	10340	30	12040	Latorre et al. 2013
Quebrada Maní 12	Stratum 3	UCIAMS 89022	Animal coprolite	10360	30	12100	Latorre et al. 2013
Quebrada Maní 12	Stratum 5	UCIAMS 84347	Charcoal	10365	25	12100	Latorre et al. 2013
Pampa Ramadita 5	Test pit 1/1A-R1	UCIAMS 165640	Plant material	10370	30	12140	This study
Pampa Ramadita 5	Test pit 1/1B-R3	UCIAMS 165642	Plant material	10425	30	12230	This study
Quebrada Maní 32	S88W45, level 4	UCIAMS134395	Plant material	10445	45	12240	This study
Quebrada Maní 12	Stratum 2	UCIAMS 89019	Plant material	10505	25	12420	Latorre et al. 2013
Quebrada Maní 12	Stratum 2	UCIAMS 89458	Marine shell	10655	25	11410	Latorre et al. 2013
Quebrada Maní 12	Stratum 2	UGAMS 7049	Charcoal	10800	30	12700	Latorre et al. 2013
Quebrada Maní 12	Stratum 4, feature 13	UCIAMS 89018	Charcoal	10930	30	12750	Latorre et al. 2013
Quebrada Maní 32	S88W45, level 4	UCIAMS 134400	Charcoal	12540	60	14710	This study
Quebrada Maní 32	S88W45, level 3	UCIAMS 134401	Charcoal	12580	50	14830	This study
Chipana 1	Test pit 3, E2B	UCIAMS	Carbonated plant	12750	35	15140	Herrera 2017
Chipana 1	Test pit 5, E7	UCIAMS 145147	Plant materia	14030	680	16880	Herrera 2017
Pampa Ramadita 5	Test pit 1/1A-R1	UCIAMS 165641	Charcoal	14160	45	17180	This study

* Terrestrial samples were calibrated using the SHCAL13 curve. Marine samples using Marine13 curve assuming a local r effect of 367 ¹⁴C yrs BP (±198) according to Latorre et al. (2016).

sourced from the Altos de Pica Formation (in the northeast section of the PdT) are of good knapping quality and are commonly found on the surface at camp localities and dispersed over the landscape (Latorre et al. 2013).

Another common lithic raw material is a white opaline silica (Blanco and Tomlinson 2013) that was quarried and collected from Cerro Chipana, a huge quarry site next to Chipana-1 (Figure 2). At this particular workshop raw material was transformed into advanced stages of large biface artifacts (Herrera 2017), which were then exported to neighboring sites like PR5, PR7, QM12, QM32, QM35 and reworked; creating a circulation of material between 20 and 30 km from the Cerro Chipana quarry.

(b) Animal resources

Bone archaeological remains show that large artiodactyls, including guanaco (*Lama guanicoe*) and possibly vicuña (*Vicugna vicugna*), along with medium-sized rodents such as *tuco tuco* (*Ctenomys* sp.) and chinchilla rats (*Abrocoma* sp.), as well as a few birds were consumed. It is possible that these animals were locally available and hence locally hunted, as they could be attracted to the paleowetlands, making the camps strategic locations for foraging wild resources. Some of the camelid remains consist of neonates, suggesting that hunters might have been present during the early wet season (December-January) when these animals are born. This does not rule out the entry of fauna from the highlands, as is suggested by isotope analyses on animal fiber – discussed below – that indicate highlands origin for some of the bone remains. Moreover, the fragmented nature of the faunal assemblages suggests intensive consumption of the animals as well as the weathering of the bones by salts as these were exposed to hyper arid conditions.

(c) Plant fiber yarn

Yarn and other remains of processed plant fibers were found at excavated stratigraphic levels from QM32. A few elements (n=8) of cotton and another unidentified plant fiber, locally cut and gathered were employed to prepare knots, twisted fiber and Z spun yarn, made through further processing or disintegration of the fiber. One sample of cotton (monochrome strand Z) was isotopically analyzed and had a $\delta^{13}\text{C}$ value of -24.1‰ . Relative to cotton fibers from the Azapa valley dated to the Formative Period (average $\delta^{13}\text{C} = -23.2\text{‰}$) this lower value for the single PdT fiber

may be indicative of the wetter conditions in this region as discussed previously. The $\delta^{13}\text{C}$ values of C3 plants (such as cotton) are sensitive to water availability, with low water availability producing relatively high (less negative) $\delta^{13}\text{C}$ values in plant tissues (Farquhar and Richards 1984; Stewart et al. 1995).

(d) Plant resources

Freshwater was widely available across these ravines. Consequently, riparian vegetation supported either by surface runoff or groundwater discharge was available. These ecosystems included tree (*E. angustifolia*, *S. molle*, *M. pavonis*, *P. tamarugo*, *Bacharis scandens*) and shrub (e.g. *Caesalpinia aphylla*, *Atriplex* spp.) species that provided fuel for the camps (Gayo et al. 2012; Joly et al. 2017; Nester et al. 2007). Likewise, several herbaceous plants were also present as archaeological refuse consumed in the open camps, including *Typha*, Cyperaceae, *Chenopodium*, *Cisthante* sp., *Cortaderia atacamenis*, Poaceae, and *D. spicata* (Gayo et al. 2012), which have a variety of uses such as fodder, food, medicinal, tinctorial, construction and as raw materials for cordages (Villagrán et al. 1999; Villagrán et al. 2003).

(e) Pigments

Pigments were also circulated within the PdT, although their origins are still unknown. No chemical analyses have been carried out to identify their origin and compare them with the chemical composition of the early pigments mined from the interior of the coast of Taltal south of the PdT (Salazar et al. 2011), and contemporaneous with their camps.

Regional networks

Based on material introduced from the coast and the high Andes, found in small quantities in most of the open camps and the workshop-quarry, we estimate that people from the PdT organized or were a part of regional social network of interaction with access directly or indirectly to the Pacific coast and the Andes (Figure 1). We also estimate that the acquisition of foreign items was embedded or was part of more complex social interactions, not materialized in archaeological material, which are discussed below.

Coastal network

This coastal regional network of interaction integrated the Pacific coast located 60-80 km to the

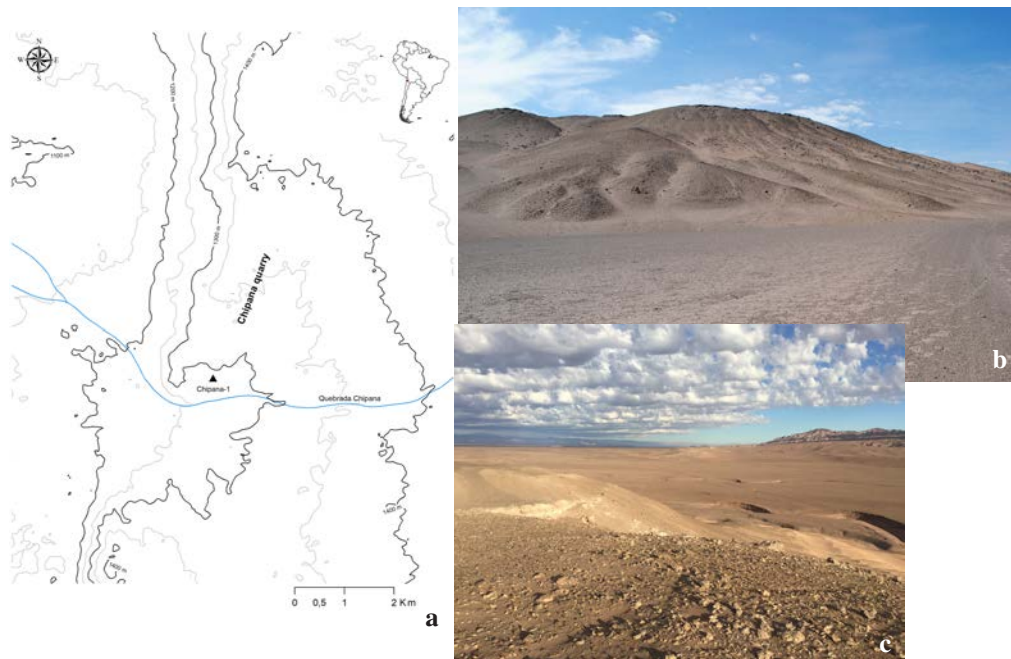


Figure 2. Chipana lithic quarry/workshop: (a) plan view of Chipana canyon, quarry hill and Chipana-1 workshop (drawn by Alonso Maldonado after Herrera 2017); (b) South flank of Cerro Chipana with the outcrop of siliceous rocks (c) top of the outcrop hill looking toward Chipana canyon to the south east and the silver mine Cerro Challacollo (images by Calogero Santoro).

Taller cantera lítica de Chipana: (a) Ubicación planimétrica de la Quebrada Chipana, cantera y campamento taller Chipana-1 (dibujado por Alonso Maldonado tomado de Herrera 2017); (b) flanco sur de Cerro Chipana con afloramiento de rocas silíceas; (c) vista desde la cima de la cantera hacia la Quebrada Chipana en el sur este y Cerro Challacollo con mina de plata hacia el sur oeste (imágenes de Calogero Santoro).

west. From this network hunter-gatherers obtained a selection of shells from marine benthic mollusks and cobbles, that were modified.

(a) Shells

The following small shells have been found in the PdT: *Nassarius gayi* (cf. *Priene scabrum*), cf. *Leukoma thaca*, *Crepidatella dilatata*, and litorinids (Figure 3). *Fissurella crassa* and *Concholepas concholepas* of larger size have also been identified. These ecofacts and artifacts were found in the stratigraphy and the surface of QM12, QM32, and QM35. In Chipana-1 we found only *C. concholepas*. Additionally, the small species *Feliciliva peruviana*, cf. *P. scabrum* litorinids was found on the surface of all of these sites except Chipana. At PR4, PR5, and PR7 sites, no marine shells have been identified. With the exception of *C. concholepas* and *L. thaca* these species are for the most part infrequently found in Holocene archaeological shell middens of the hyper arid coast of northern Chile (Bird 1943). Yet, they are common in modern natural assemblages (Guzmán et al. 1998; Laudien et al. 2007), as well as in the Pleistocene fossil record of Peru and

northern Chile (Ortlieb et al. 1995; Paskoff et al. 1995; Rivadeneira and Carmona 2008).

N. gayi (Figure 3a) is a non-edible small snail (up to 14 mm in length) that inhabits sandy and muddy sediments from 0-15 m depth with a modern distribution from Isla Lobos de Afuera in Peru (6°S), to Cape of Horn in southern Chile (55°S) (Guzmán et al. 1998; Marinovich 1973; Reid and Osorio 2000). Its presence in coastal shell middens of northern Chile has been described for Taltal between 8,000-5,600 cal yr BP (Olguín 2013). This is the most represented mollusk at the QM12 site (n=30). All complete specimens have a distinctive human-made hole in the body of the shell, and were probably used as ornaments. One of these was directly dated to 12,200 cal yr BP (a 400 years reservoir correction was applied to the dated sample) (Latorre et al. 2013), and was coeval with the rest of the dated materials of the site.

F. peruviana (= *Oliva peruviana*, Figure 3b) is a non-edible taxon that inhabits subtidal water in soft bottoms, between 4-10 m depth, with a modern distribution from Sechura Bay, Peru (5°S) to Lota in southern Chile (37°S). These taxa reach up to 55 mm in length (Guzmán et al.

1998; Osorio 2002). The oldest record of *F. peruviana* in coastal shell middens is 9400-8100 cal yr BP in Huentelauquén, central Chile (Vásquez et al. 1998). Because this species does not have alimentary properties, it was probably used for ornamental purposes.

L. thaca (= *Prothaca thaca*, Figure 3c) is an edible taxon that inhabits soft bottoms, from the intertidal to 15 m depth, reaching sizes up to 108 mm length (Huber 2010). This species is distributed from Chicama, Peru (7°S) to the Chonos Archipelago in southern Chile (43°S) (Alamo and Valdivieso 1997). This taxon is currently exploited by the artisanal fleet and consumed by humans along the coast of Chile (Jerez and Figueroa 2008). The oldest record of this species in shell middens of Chile is ca. 9,000 cal yr BP, in Los Vilos in central Chile (Báez et al. 2003), but its presence in shell middens of northern Chile starts at ca. 7100 cal yr BP (I-9817) in Camarones (Niemeyer and Schiappacasse 1979).

C. concholepas or *loco*, the Chilean abalone, is an edible taxon native to the Pacific coast of Chile and Peru with a modern distribution between 5°S to 55°S. The species inhabits the low intertidal zone to 50 m depth (Häussermann and Försterra 2009) and reaches sizes up to 179 mm in length (Vermeij 2012). The oldest record of *loco* in the shell middens of Chile is between 12,570-12,140 cal yr BP at the Los Rieles site in central Chile (Jackson et al. 2012).

(b) Cobbles

Rounded, and often highly elongated cobbles (Figure 4), were most likely selected by humans from Pacific coastal environments and transported to the PdT by direct or indirect mechanisms to be used as hammer instruments due to their hardness. These cobbles are highly polished, likely due to abrasion by waves on the coast. Such well-rounded and hard cobbles are uncommon in the PdT as large and prolonged stream discharge events, critical for rounding and polishing stones, are infrequent. The PdT is too proximal to the adjacent Andes for such cobbles to form. Indeed, the majority of well-rounded cobbles found profusely in the PdT streams are typically comprised of soft ignimbrite lithologies, which are unusable as hammer stones.

Highland network

Andean regional networks of interactions resulted in human transportation of raw materials (obsidian, chalcedony, and camelid fiber) to the PdT sites. Moreover, highland projectile point types have been identified, indicating that the acquisition of physical material may have been linked to the transferring of certain technological knowledge, among other social businesses.



Figure 3. The coastal circuit of interaction showed by shells of the marine benthic mollusks from the Pacific littoral 60-80 km to the west from Pampa del Tamarugal: (a) *Nassarius gayi* from QM12, (b) *Felicioliva peruviana* from QM35, and (c) *cf. Leukoma thaca* from QM35.

El circuito costero de interacción evidenciado por conchas de moluscos bentónicos del litoral Pacífico, 60-80 km al oeste de la Pampa del Tamarugal: (a) Nassarius gayi de QM12, (b) Felicioliva peruviana, de QM35, y (c) cf. Leukoma thaca de QM35.

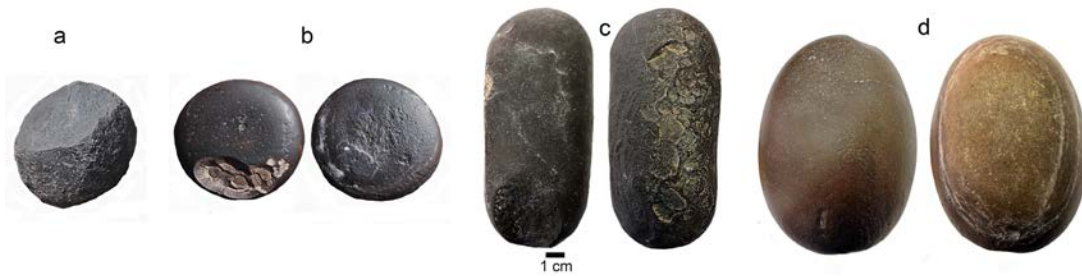


Figure 4. Coastal rounded cobbles used as hammer stones and found in different archaeological sites in Pampa del Tamarugal: (a) Chipana, (b-d) Quebrada Maní 35 (images by Wilfredo Faudes [a and b] and Paola Salgado [c and d]).

Cantos rodados de la costa usados como percutores, encontrados en distintos sitios arqueológicos en la Pampa del Tamarugal: (a) Chipana, (b) y (c) Quebrada Maní 35, (d) Quebrada Maní 12 (imágenes de Wilfredo Faudes [a y b] Paola Salgado [c y d]).

(a) Obsidian

Obsidian is a high-quality volcanic raw material typically found in the highlands. At least five different obsidian sources have been characterized in the neighboring southern Altiplano, including Pelun, Salar de Tara, Cerro Kaskio, Laguna Blanca/Zapaleri and Caldera Vilama (Capriles et al. 2018; Seelenfreund et al. 2010; Yacobaccio et al. 2004). The closest known obsidian source to Quebrada Maní is Cerro Kaskio, situated approximately 150 km to the east. Cueva Bautista, a high-elevation temporary camp—located at the same latitude of our study area—was occupied around the same time as the late Pleistocene occupations of the PdT. It is located 15 km away from Cerro Kaskio, and contains abundant evidence of Cerro Kaskio obsidian (Capriles et al. 2016).

Energy-dispersed x-ray fluorescence and instrumental neutron activation analyses suggest that the QM12 obsidian flake and a distal fragment of a triangular blade projectile point from SLI17 correspond to two different but still unidentified obsidian sources. Furthermore, a retouched obsidian flake from a somewhat later (early Holocene) human occupation in Quebrada Blanca, an open camp located between the PdT and Cueva Bautista (Osorio, Capriles, et al. 2017), was sourced to Salar de Tara (Figure 1).

The date of obsidian flake from QM12, as it was recovered from the A horizon beneath a desert pavement, would fluctuate between ca. 12,200 and 11,900 cal yr BP, corresponding to the temporal period defined for the site. At SLI17 (a site located in Salar de Llamara, a late Pleistocene fresh water basin, hydrographically linked to Quebrada Mani, and currently a dry salt pan) the blade of a large obsidian projectile point, of still unknown chronology, was recovered from the surface, embedded in the saltpan next to other lithic debitage of different raw materials (Figure 5a). As these former lagoon ecosystems collapsed at ca. 10,000

to 9000 cal yr BP (Pfeiffer et al. 2018), it is likely that this obsidian point was brought before that time, roughly contemporaneous or slightly later than the occupation of QM12. Transportation of small quantities of obsidian from the high Andes was not rare at open camps in Pacific coastal region of southern Peru (Rademaker et al. 2013), contemporaneous with QM12, which are thought to be part of exchange networks that included the circulation of processed fish (Reitz et al. 2016).

Similarly, south of the PdT, late Pleistocene hunter-gatherers living on pre-Andean ecological zones (2000-3800 masl) also obtained obsidian from highland environments linked to paleolake habitats that were gradually colonized based on a seasonal network of interaction (Grosjean et al. 2005; Loyola et al. 2017; Núñez et al. 2002; Núñez et al. 2018).

(b) Chalcedony

Chalcedony is another raw material with no local sources, which is consistent with its rare occurrence in PdT archaeological sites. We found on the surface of PR5 the base of a projectile point manufactured on a fine-grained brownish lustrous chalcedony (Figure 5b). A few other flakes of this same exogenous raw material have been found in QM32, QM34 and QM35. The second most abundant raw material in the late Pleistocene occupation of Cueva Bautista in the highlands of Bolivia, following Cerro Kaskio obsidian, is a fine-grained jasper-like lustrous chalcedony that ranges in color from beige to burgundy. This chalcedony is macroscopically very similar to the raw material found in the PdT, but as chalcedony can be macroscopically similar and come from different sources, further analyses are required to confirm that beyond its rarity, it was a highland raw material.

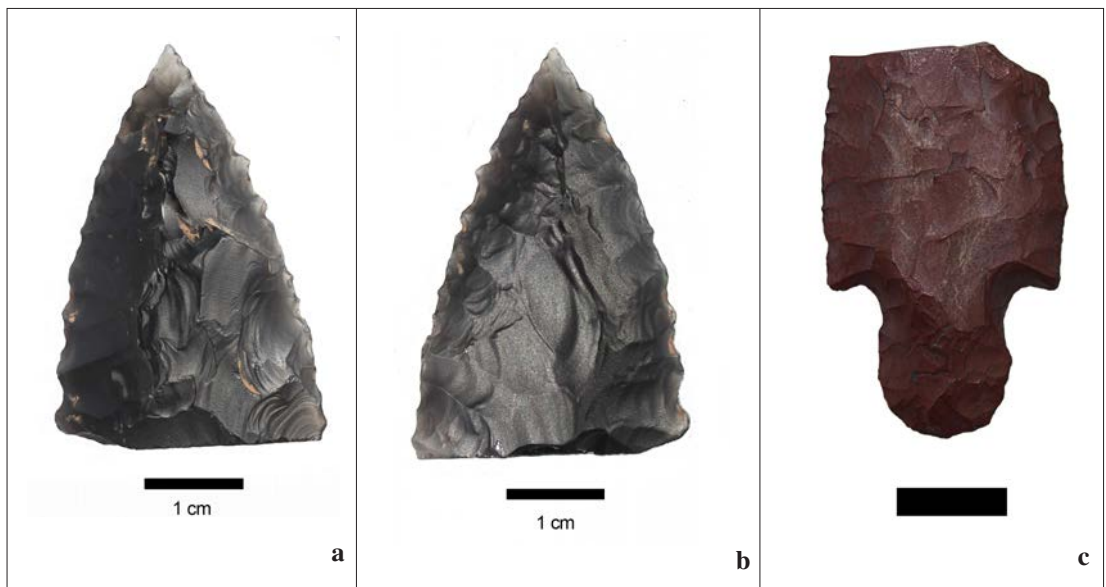


Figure 5. The Andean circuit revealed by highland lithic raw materials: (a) distal tip of an obsidian projectile point registered at Salar de Llamara 17; (b) base of a projectile point manufactured on a fine-grained marron lustrous chalcedony found in Pampa Ramadita 5 site in Pampa del Tamarugal.

Circuito andino evidenciado por materias primas líticas de tierras altas: (a) extremo distal de una punta de proyectil de obsidiana registrada en Salar de Llamara 17; (b) base de una punta de proyectil elaborada sobre cuarzo lustroso de grano fino, encontrado en el sitio Pampa Ramadita 5, Pampa del Tamarugal.

(c) Projectile point types

Another proxy for the Andean networks of interaction is represented by projectile point types (Patapatane and Tuina) found both in stratigraphy and the surface from open camps in the PdT: QM12, Chipana-1, and QM35. These projectile point types are common in Early Archaic sites in the highlands of northern Chile. The Patapatane type is common in Andean archaeological sites from southern Peru and northern Chile (e.g., Asana, Caru, Patapatane, Hakenasa, and Las Cuevas). The Tuina type form is common in archaeological sites from the Central Atacama (e.g., Tuina, Tambillo, Punta Negra, and Alero El Pescador sites). It has been also recognized in northwestern Argentina (Herrera 2017; Herrera et al. 2015; Latorre et al. 2013; Núñez et al. 2016; Osorio, Steele, et al. 2017; Santoro and Núñez 1987).

(e) Yarn of animal fiber

Yarn and other remains of processed animal fibers were found at excavated stratigraphic levels from QM32. The major technical innovation was the processing of animal fleece and the production of

primary textile structures, such as yarn, felted fleece, and other evidence of animal fiber processing (n=126). Raw materials may have included fibers from *guanaco*, *vicuña*, and rodents, along with human hair. Technical action involved cut-shearing, as shown in fiber with few modifications related to procurement or extraction possibly from animal hides; felted fleece, felt stitching, fleece spinning, and hand spinning and twisting or plying, as shown by single yarns, 2 ply yarns and knotted threads. Specifically, a sample of 2-ply yarn found in situ in QM32 was dated to 11,270 cal yr BP (Table 1).

Carbon isotopic analyses of these fibers (fleece and yarn) show a very high contribution of C3 plants, consistent with a highland origin. Considering the prevailing wetter conditions in the high Andes at this time (Gayo et al. 2012), we would expect the Altiplano to be characterized by very few C4 plants (Still et al. 2003). We analyzed 12 samples of animal fiber, 10 possibly camelids (*vicuña* and *guanaco*) and 2 rodents (*chinchilla* or *vizcacha*). The fiber samples analyzed include 3 yarn, 5 fleece, 2 twisted fleece, 1 felted fleece, 1 stitched fleece with remains of red pigment. Comparatively, camelid bone collagen from Tiwanaku in the Lake Titicaca basin produced comparable $\delta^{13}C$

and $\delta^{15}\text{N}$ values relative to these animal fibers from PdT (Szpak 2013). Adjusting for hair-collagen differences in isotopic discrimination (Szpak et al. 2014) the $\delta^{13}\text{C}$ values range between -21.0 and -18.2‰ and the $\delta^{15}\text{N}$ values range between $+6.2$ and $+8.7\text{‰}$ (Figure 6, and Supplementary Material 1).

Trans-Andean network

Data for a trans-Andean connection comes from a piece of wood (ecofacts) found in layer 3 of QM32 (the larger one measuring 8 cm long and weighing 21.6 gr.). The poor-preservation prevented the determination of whether this pieces formed part of any artifact. There is no direct dates for this wood fragments, but several radiocarbon samples from stratigraphic layer 3 of QM32 site were dated to the late Pleistocene (Table 1).

Anatomical analysis on the larger wood fragment identified it as exotic silk floss tree (cf. *Ceiba* spp. very similar to *Ceiba speciosa*; Figure 7). Although, a tangential section was observed due to the poor condition of the tissue, it was possible to identify the following anatomical characteristics: simple vessel perforations plates, alternate inter-vessel pits, polygonal shape of alternate pits, fibers of very thin walled, large rays commonly > 10 seriated, ray height $> 1\text{mm}$, rays with procumbent, square and upright cells mixed throughout the ray, sheet cells (IAWA-Committee 1989; Richter and Dallwitz 2000 onwards; Tortorelli 1956). These anatomical features are unequivocally attributable to *Ceiba* spp.

Ceiba spp. (silk floss tree or *palo borracho*) is a native Malvaceae (subfamily Bombacoideae) species from the Atlantic seasonal semi-deciduous forest and tropical savannas from eastern South America, where mean annual rainfall ranges between 1,500 and 1,000 mm/yr, and the mean annual temperature exceeds 18°C (Cruz Ruggierom et al. 2002; Killeen et al. 1998). Although paleoclimate data suggest a two-to-four-fold increase in rainfalls during the CAPE II event (Gayo et al. 2012; Latorre et al. 2006; Pfeiffer et al. 2018), the magnitude for such change was not enough to support local populations of *Ceiba* spp. either at the PdT or over the western Andean slope (Figure 7). But more importantly, paleoclimate transformations in the PdT were related to reduced temperatures and positive hydroclimate anomalies brought about amplified surface and groundwater discharge instead of increased local precipitation (Gayo et al. 2012; Pfeiffer et al. 2018). The fact that hyper arid conditions

(i.e. no local rainfalls) remained stable during the CAPE II at PdT, then the record of *Ceiba* spp. wood-fragments in the archaeological context of QM32 necessarily implies intended anthropogenic transport.

Discussion

Traveling, networking for moving objects, people, and ideas have been key social interactive behaviors in human history (Clarkson et al. 2017; Dillehay 2013; Dillian and White 2010; Hirth and Pillsbury 2013). In South America, it seems that since the early colonization of the continent people were linked to a broad network that directly and indirectly connected human groups from a wide range of dispersed ecosystems. This strategy allowed them to get access to a variety of exotic utilitarian (subsistence) and non-utilitarian resources, which in turn helped them to cope with environmental instabilities and food shortages; to reinforce social linkages, political alliances, and kinship extension (including mate exchange); and to avoid conflicts; all of which contributed to social reproduction. The value of transporting non-utilitarian and utilitarian goods is not intrinsic to the good itself. After all, this analytical dichotomy between “necessity and sumptuary” resources is culturally mediated. As the flow of utilitarian and non-utilitarian resources and objects are embedded in social and cultural practices, the decisions of movement do not only concern subsistence (Gould and Saggars 1985; Lovis et al. 2005; Newlander 2012; Politis 1996; Whallon 2006). Local and exotic goods found in the late Pleistocene archaeological record of the PdT were used for a variety of social purposes and functions, including food, tools, personal adornment, and other objects of unknown function.

Almost all the mollusks found are small and many have small holes, which suggests that they were not a primary food source, but selected for other purposes, such as ornamental and ritual with the exceptions of *C. concholepas*, *Fissurella* spp., and *L. thaca*. The small size of *N. gayi* likely precluded its use as a food source. It was, however, an ideal primary material for body adornment (Correa 2016). *F. peruviana* was used as a funerary offering in the Late Archaic Tiliviche cemetery (Standen and Núñez 1984), and became very common since the Formative period ca. 3600 cal yr BP onwards in funerary contexts of northern Chile. These items were brought from the Pacific coast 60-80 km away, and its special purpose is also suggested by its low frequency. Other item brought from the coast, but with utilitarian purpose were the hard-rounded cobbles. They were

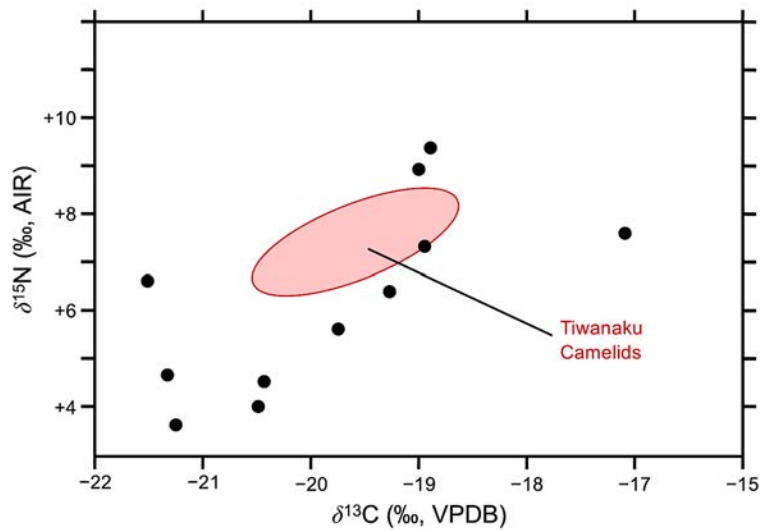


Figure 6. Carbon and nitrogen isotopic compositions of animal fiber samples from Pampa del Tamarugal. For comparative purposes, the standard bivariate ellipse for camelid bone collagen from Tiwanaku is shown to represent camelids consuming a high proportion of C3 plants. The $\delta^{13}\text{C}$ values of the Tiwanaku camelid bone collagen have been adjusted by -1.3‰ to account for the difference in diet-tissue discrimination between hair and bone collagen as described in the text.

Composición isotópica de carbono y nitrógeno de muestras de fibras animales de Pampa del Tamarugal. Con fines comparativos, se muestra la elipse bivariada estándar de colágeno de huesos de camélido de Tiwanaku, que consumían una alta proporción de plantas C3. Los valores de $\delta^{13}\text{C}$ del colágeno óseo de Tiwanaku se han ajustado en $-1,3\text{‰}$ para dar cuenta de la diferencia en la discriminación entre el tejido y la dieta entre el cabello y el colágeno óseo como se describe en el texto.

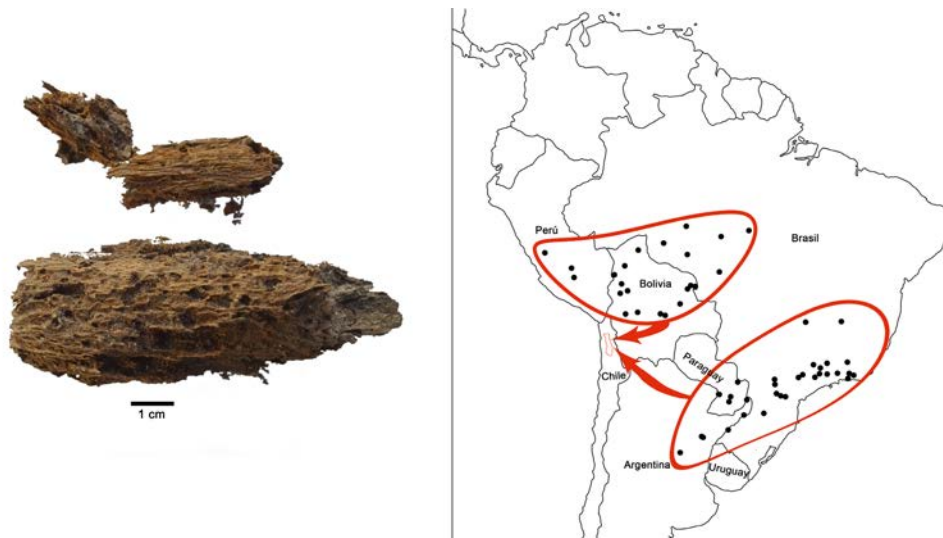


Figure 7. (a) Archaeological wood sample identified as *Ceiba* spp. (Gibs and Semir 2003); (b) Distribution of *Ceiba speciosa* in the Amazonian tropical and subtropical zones, away from Pampa del Tamarugal.

(a) Muestra de madera arqueológica identificada como *Ceiba* spp. (Gibs y Semir 2003); (b) Distribución de *Ceiba speciosa* en las zonas tropicales y subtropicales amazónicas, alejadas de la Pampa del Tamarugal.

used as percussion tools in preparing stone artifacts. Suitable stones for hammering are not geologically available in the PdT.

Items from the highlands included obsidian, chalcedony, and camelid fiber, also found in small quantities. As good lithic raw material is locally available, the introduction of foreign stones was not conditioned by the absence of this kind of supply. Animal fibers were also locally available but, according to isotope analyses, some fiber for the production of primary textile structures came from the highlands. Given that different stages of the operational sequence for yarn production were identified, we deduce that the raw material was imported and then locally processed. This interpretation is reinforced by the presence of textile structures made out of local plant fiber (cotton and other unknown taxon), which indicates that these people had the technological knowledge to produce threads, the primary structure for fabrics.

The piece of wood of a tree species (*Ceiba* spp.) that today occurs in the tropical and subtropical forests to the east of the Andes, ca. 600 km away, is an item that does not fill the absence of wood raw material. By the end of the Pleistocene the PdT had a good coverage of trees with appropriate wood for tool making. Besides, *Ceiba* spp. provides a soft and light wood which function in this context is unknown.

The particular set of exotic items found in the PdT, although in small quantities, imply that people were involved in broad social networks that may have included exchange, logistic movements, marriages, and sporadic visits, among others. For the acquisition of these materials, they needed to establish links with other populations, and therefore, with other cultural worlds, languages, landscapes, and ideologies.

Like some contemporaneous hunter-gatherers (Politis 1996), the late Pleistocene hunter-gatherers in the PdT needed to manage different scales of territory, that ranged from a local social territory well known by a band, to very distant lands, known and visited by possibly few members of the group. Within this vast territory, people obtained their supplies from different resources to be incorporated into their socio-cultural subsystems. The mechanisms to access and obtain goods, nevertheless, remain a dilemma. As it has been noticed by several investigators the detection of exotic or imported goods is not enough to distinguish between direct access by mobility and indirect access by exchange (e.g., Costin 2001, Close 2000, Hodder 1982; Pallo and Borrero 2015). As far as we know, however, archaeological indicators evaluated to distinguish both mechanisms

are not conclusive. For example, the ratio between the distance to the source of origin and the curve of frequency of the imported objects, from short distances versus objects of long-distance sources do not necessarily represent the extremes of mobility and exchange patterns, respectively. Australian ethnographic and archaeological cases, among others, provide abundant data that show that long-distance movements covering several hundred km were practiced to obtain socially valuable objects (and therefore not plentiful), along with short and long-distance exchanges for other important items (Gould and Saggars 1985; McBryde 1984; Mulvaney 2002; Veth 2008). Next, we hypothesize the possible ways these mechanisms occurred.

For the **local network**, the current archaeological data from the PdT allow us to suggest that people managed three basic levels of territorial information as suggested by Rockman (2003:4): locational, limitational and social knowledge. At the locational level, people certainly recognize the places and physical characteristics of local resources for subsistence (i.e., lithic outcrops, wood, game, plant, wetlands). At the limitational level people were familiar with the range of distribution and reliability of local resources, the costs of acquisition, and its usefulness. At the third level, the PdT people created a social knowledge, as they settled and moved throughout the landscape revisiting more regularly camps located in the proximal section of the fluvial fan of the *quebradas* that drain into the PdT. Their familiarity with this territory increased substantially, conceptually defining the components they recognized, those that were utilized and those that were not, creating a complex human landscape. Due to the predicted low population density in the PdT by the end of the Pleistocene, we estimate that the procurement, translation and integration of local resources by hunter-gatherer societies could have occurred through both logistical and residential mobility.

Regional networks of interaction required different sorts of knowledge and movements. Information would likely have been gathered from social networks linked to other social groups, settled along the Pacific coast or the high Andes. The introduction of low quantities of high-quality Andean lithic raw materials may have occurred through mobility of the PdT groups to those external ecosystems. Alternatively, people may have accessed to the exotic items through large-scale network of exchange or down-the-line trade. For obsidian found in late Pleistocene open camps of the southern Peruvian Pacific coast, which originated more than 130 km toward the Andes, it has been suggested that it was obtained through the exchange of processed fish within

a regional network (Rademaker et al. 2013; Reitz et al. 2016). Exchange or down-the-line trade in intermediate territories is a feature assigned to well-established Holocene hunter-gatherers in South America (Dillehay 1999). Considering that the long distance transported items had no food value, and some of them were non-utilitarian and were low frequency items, it may indicate that the purpose for making the effort of accessing coastal and Andean goods was probably motivated by social gatherings (e.g., marriages and information exchange). This means that in these and other social gatherings, exotic items could be exchanged to reinforce social bonds that were crucial for the sustainability of late Pleistocene hunter-gatherers living in the shifting and challenging ecosystems of the PdT. The finding of exotic material itself, however, should not be considered as conclusive evidence to distinguish between exchange and direct access. Nonetheless, it should be considered, however, that less than 100 km separate the PdT and the Pacific coast to the west, and the Andes to the east, thus it may be possible that human groups directly reached the resources of these ecosystem through logistic mobility circuit (Figure 1). This interpretation would need research with a larger geographic scope.

Late Pleistocene hunter gatherers of the PdT managed to obtain resources located beyond the Andes into the tropical lowlands, as is indicated by the taxonomic identification of tropical wood (*Ceiba* spp.). In other words, it seems likely, that people were part of larger, complex long-distance networks that enabled the circulation of such materials. More importantly, though, was the possibility of the existence of extended networks of interaction for sharing knowledge and for establishing social bonds beyond the band level. Very recent genetic research that examined South American population structure and pre-Hispanic population displacements, utilizing mitochondrial DNA haplogroups of 4200 subjects of extant mixed populations of Mexico, Costa Rica, Venezuela, Colombia, Ecuador, Peru, Bolivia, Brazil, Argentina and Chile, showed that the territories of southern Peru, northern Chile and highland Bolivia were colonized by genetic flows from the Amazon basin (Rothhammer et al. 2017), which in turn reinforces the (Lathrap 1970) hypothesis that the upper Amazon was peopled by upstream population movements using the Amazon river network as a waterway.

Conclusions

The archaeological evidence presented here shows that various exotic, utilitarian, non-utilitarian and edible

goods were introduced and consumed in the PdT (lithic raw materials, wood, animal and plant fibers for tool elaboration, and mollusks for food and other purposes). They were carried from the Pacific coast, the Andean highland and the tropical forest, and were integrated to the resources gathered locally within the PdT. The specific mechanisms for the circulation of these items are uncertain. The distribution of material may have occurred through long-term incursions of people from the PdT, and the encounter with individuals from other ecosystems inside or outside the PdT. These encounters could have happened within rather informal networks of interaction, as suggested by the scarcity of the exotic objects. Connections with the tropical forest, more than 600 km away, were the consequence of even larger networks of interaction that involved several groups moving within and between ecosystems. Although most of the identified resources could be classified within the “utilitarian” world, there are elements that do not hold nutritional value or cannot be used as raw materials for manufacturing tools. Thus, they were carried because of other social purposes and functions. Besides the circulation of exotic items, the encounter with other peoples should have served to share knowledge and experience on plants and animal behavior, geography, information in managing raw materials and technological practices, as well as marriage arrangements, collaborative social actions. Moreover, the down-the-line transportation of goods should have propitiated also the migration of women and men that interacted along the way from the tropical forest to the Pacific and vice versa.

One of the marks of the functioning of a long-range system of interaction is that beyond the economically necessary transported goods, the distribution of alternative items is also served. Their significance, however, is not obvious, as they may be related to spiritual or ritual necessities or may be the basis for different classes of alliances. The maintenance of local, regional, and supra-regional networks of interaction should have required different kinds of mobility practices involved in the social life of the groups who initially colonized the Atacama Desert. It should be mentioned that rainfall in the highlands during the late Pleistocene was two or three times more abundant than today. These climatic conditions reduced the stark discontinuities of the ecological zones involved in the networks of interaction utilized by hunter-gatherers between the Pacific coast and the tropical forests. Fresh water and natural routes such as rivers and available plants and animals would have made travel more feasible. As connectivity

was better during the late Pleistocene, it is likely that the continuous landscapes with different resources facilitated a pan-Andean connection beyond the Altiplano. In other words, the late Pleistocene-early Holocene inhabitants of the PdT had the possibility to be part of a broad exchange network that allowed them access to a diversified list of rather conspicuous items brought from both the eastern and western slopes of the Andes.

In sum, the circuit of movement implied in the circulation of the exotic items is still uncertain, but it can be imagined that people at least managed a local circuit of mobility within the PdT of ~200 km in length (north to south) and ~100 km in width (east to west). Connections with the external world such as the coast (ca. 60-80 km to the west) and the highland (ca. 80-150 km to the east) may have involved direct incursions to these ecosystems or the encounter with other groups of people in intermediate territories. Connections with the tropical forest, more than 600 km away, were possibly the consequence of down-the-line exchange networks that involved several groups in the circulation. Explanations for the introduction of exotic “non-utilitarian” objects, with non-dietary value, into the PdT would be that: (a) as exotic goods they had intangible meanings and were used within socio-cultural performances (i.e.,

birth and death of group member; marriage; investiture of a new leader; healings); (b) by forming part of these and other behavioral patterns, the action of introduction of these material objects allowed them to create bonds with outside groups to cope with social strategies for the survival and reproduction of the groups; (c) exchange included also sharing meanings imbedded in these objects and transferring information about the outside world.

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Supplementary Material 1: Methods – Stable Isotope Analysis

Stable Isotope Analysis – Sample Preparation

Samples were cleaned of any visible foreign matter with tweezers and then sonicated in Type I water for 1 h, then in 2:1 chloroform:methanol for 1 h. After removing the solvent the samples were air dried under normal atmosphere for at least 24 h.

Stable Isotope Analysis – Instrumentation and Analytical Uncertainty

Carbon and nitrogen isotopic and elemental compositions were determined using a Nu Horizon continuous flow isotope ratio mass spectrometer. Sample measurements were calibrated relative to VPDB ($\delta^{13}C$) and AIR ($\delta^{15}N$) using USGS40 and USGS41a (Table S1; Qi et al., 2003; Qi et al., 2016).

Table S1. Standard reference materials used for calibration of $\delta^{13}C$ relative to VPDB and $\delta^{15}N$ relative to AIR.

Standard	Material	Accepted $\delta^{13}C$ (‰, VPDB)	Accepted $\delta^{15}N$ (‰, AIR)
USGS40	Glutamic Acid	-26.39±0.04	-4.52±0.06
USGS41a	Glutamic Acid	+36.55±0.08	+47.55±0.15

The following standards were used to monitor accuracy and precision (Table S2). The isotopic compositions for the internal keratin standard represent long-term averages.

Table S2. Standard reference materials used to monitor internal accuracy and precision.

Standard	Material	Mean $\delta^{13}C$ (‰, VPDB)	Mean $\delta^{15}N$ (‰, AIR)
SRM-1	Caribou bone collagen	-19.36±0.11	+1.81±0.10
SRM-2	Walrus bone collagen	-14.76±0.12	+15.59±0.11
SRM-4	Gluten	-26.76±0.08	+5.25±0.11
SRM-14	Polar bear bone collagen	-13.66±0.07	+21.62±0.12

Table S3 summarizes the mean and standard deviation of carbon and nitrogen isotopic compositions for all check standards, as well as the standard deviation for all calibration standards – the mean of the calibration standard for an individual run is predetermined to calibrate the data.

Table S3. Mean and standard deviation of all check and calibration standards for all analytical sessions containing data presented in this paper. Note that means for calibration standards are not presented as they are pre-determined to be equal to the known value.

Run ID	Standard	n	$\delta^{13}C$ (‰, VPDB)	$\delta^{15}N$ (‰, AIR)
18-03	USGS40	5	± 0.13	± 0.06
18-04	USGS40	5	± 0.04	± 0.05
18-03	USGS41a	5	± 0.14	± 0.06
18-04	USGS41a	5	± 0.12	± 0.06
18-03	SRM-4	5	-26.72 ± 0.12	+5.28 ± 0.04
18-03	SRM-2	4	-14.84 ± 0.08	+15.62 ± 0.07
18-03	SRM-14	4	-13.70 ± 0.09	+21.59 ± 0.11
18-04	SRM-1	4	-19.34 ± 0.07	+1.82 ± 0.07
18-04	SRM-2	4	-14.77 ± 0.03	+15.58 ± 0.09
18-04	SRM-14	4	-13.61 ± 0.03	+21.59 ± 0.03

One sample (#529) was analyzed in duplicate. The difference between the duplicate measurements was 0.15 ‰ for $\delta^{13}C$ and 0.14 ‰ for $\delta^{15}N$.

Analytical Uncertainty

Standard uncertainty was calculated using the method present by Szpak et al. (2017), which largely follows Magnusson et al.'s (2012) approach. Standard uncertainty was determined to be ± 0.16 ‰ for $\delta^{13}\text{C}$ and ± 0.15 ‰ for $\delta^{15}\text{N}$.

Results

The carbon and nitrogen isotopic and elemental compositions of all samples analyzed are presented in Table S4.

Table S4. Stable isotopic and elemental compositions for all samples analyzed in this study.

Lab ID	Sample ID	Taxon	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	wt%C	wt%N	Atomic C:N
518	QM32_S1E8_C2b/R2_M518	Monochrome yarn ZS	-19.74	5.64	26.6	8.4	3.69
519	QM32_S1E8_C2b/R2_M519	Monochrome yarn ZS	-18.89	9.38	15.4	4.9	3.67
520	QM32_S2E8_C2c_M520	Fleece, vicuña?	-17.08	7.61	30.5	9.4	3.78
521	QM32_S2E8_C1_M521	Fleece, with red pigment?	-18.94	7.38	31.8	9.6	3.86
522	QM32_S2E9_C1_M522	Yellowish beige fleece	-19.27	6.45	34.2	10.1	3.95
523	QM32_S2E9_C2_M523	Cotton	-24.06	-3.06	29.6	0.5	69.04
524	QM32_S1E8_C2B_M524	Z- twisted monochrome fleece	-21.32	4.65	34.2	11.7	3.66
525	QM32_S1E9_C2ab_M525	Fleece with cut marks	-18.99	8.96	34.7	11.0	3.68
526	QM32_S2E8_C2DE_M526	S-twisted monochrome fleece, vizcacha?	-20.44	4.54	36.7	11.0	3.89
527	QM32_S2E8_C2DE_M527	Vizcacha fleece-hair?	-21.51	6.65	24.3	7.2	3.94
528	QM32_S2E8_C2AB_M528	Felted fleece	-21.25	3.67	35.8	10.6	3.94
529	QM32_S2E8_C2AB_M529	Guanaco? fleece	-20.48	4.01	37.2	11.3	3.84

