

1. Title

Project Title: The trail of the llama: Pre-Columbian long-distance caravan exchange in the Atacama Highlands of South America

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2. ABSTRACT

English

The main goal of this project is to study Pre-Columbian long-distance exchange in the Atacama Highlands and neighboring areas of the Andes, focusing on the role of llama caravans. Previous studies carried out by archaeologists, ethnohistorians, and anthropologists have proposed the existence of extended exchange networks among different ecozones of the Andean Highlands during prehistoric, historic, and modern times. Frequently, these studies stressed the importance of domestic South American camelids—specifically llamas—in the development of these networks as the main vehicle for long-distance exchange journeys due to their capacity to carry weight as they travel across the Andean mountainous terrain. This project will discuss the existence and extension of long-distance caravan exchange by combining zooarchaeological methods with isotope analysis of llama remains recovered at archaeological sites located in the Atacama Highlands and adjacent areas in the current territories of Chile and Argentina.

Broadly, the project will focus on the identification of camelids' bone pathologies linked to the stress of the caravan journeys and the measurement of strontium isotope compositions on camelids' bones and teeth to be used as a proxy for palaeomobility. This approach will provide information about the use of llamas as pack animals as well as their origin and mobility patterns, which will be discussed considering previous archaeological evidence that point towards the existence of extended pre-Columbian caravan trade networks. Finally, the results of these analyses will be used to evaluate the interaction between the Atacama Highlands and neighboring areas such as the Atacama Oases (Chile) and the Quebrada de Humahuaca (Argentina) between the Early Formative and Late periods (3500 years BP to the European arrival). By focusing on the life history of caravanners' animal companions, this project will address not only those aspects related to the character of the relationships that the human groups established with these animals but also explore different aspects of social interaction among the societies that inhabited the Atacama Highlands and adjacent areas during pre-Columbian times. Hopefully, the results obtained pursuing these goals will challenge previous views about Pre-Columbian long-distance caravan exchange in this region and thus contribute to the study of ancient llama caravans in the Andes as a whole.

Español

El objetivo principal de este proyecto consiste en estudiar el intercambio de larga distancia que existió en la Puna de Atacama y áreas contiguas de los Andes en tiempos precolombinos, prestando especial atención al rol de las caravanas de llamas. Estudios previos llevados a cabo por arqueólogos, etnohistoriadores y antropólogos han propuesto la existencia de extensas redes de intercambio entre distintas ecozonas de las tierras altas de los Andes durante tiempos prehistóricos, históricos y modernos. Frecuentemente, estos estudios han destacado la importancia de los camélidos domésticos—específicamente las llamas— en el desarrollo de estas redes, señalándolos como el principal vehículo empleado para llevar a cabo viajes de intercambio a larga distancia, debido a su capacidad de cargar peso mientras se desplazan por el irregular terreno andino. Este proyecto discutirá la existencia y extensión del intercambio caravanero de larga distancia combinando métodos

zooarqueológicos con análisis de isótopos llevados a cabo sobre restos de llamas recuperados en sitios arqueológicos ubicados en la Puna de Atacama y áreas adyacentes, localizadas en los actuales territorios de Chile y Argentina.

En líneas generales, este proyecto se focalizará en la identificación de patologías óseas vinculadas al estrés de los viajes en caravana y en la medición de la composición isotópica del estroncio en huesos y dientes de camélidos para ser utilizada como indicador de paleomovilidad. Este enfoque permitirá obtener información sobre el uso de las llamas como animales de carga así como también su origen y movilidad, la cual será discutida teniendo en cuenta evidencias arqueológicas previas que apuntan a la existencia de extensas redes de intercambio caravanero en tiempos precolombinos. Finalmente, los resultados de estos análisis serán utilizados para evaluar la interacción existente entre la Puna de Atacama y áreas vecinas —tales como los Oasis de Atacama (Chile) y la Quebrada de Humahuaca (Argentina)— entre el Periodo Formativo Temprano y el Periodo Tardío —entre los 3500 años AP hasta la llegada de los europeos—. Al enfocarnos en la historia de vida de los acompañantes animales de los caravaneros, este proyecto no solo estudiará aquellos aspectos ligados al carácter de la relación que los grupos humanos establecieron con los camélidos sino que también explorará distintos aspectos de la interacción social que existió entre las sociedades que habitaron la Puna de Atacama y las áreas adyacentes en tiempos precolombinos. Finalmente, esperamos que los resultados obtenidos permitan cuestionar antiguos preconceptos sobre el intercambio a larga distancia durante los últimos 3500 años en el área de estudio y así contribuir al estudio del fenómeno de las caravanas de llamas andinas en su totalidad.

3. PROJECT DESCRIPTION

Introduction

The goal of this project is to study Pre-Columbian long-distance exchange in the Atacama Highlands and neighboring areas of the Andes, focusing on the role of llama caravans in the development of trade networks. The existence of these networks has been traditionally inferred by the ubiquitous presence of foreign objects and resources in the archaeological record of different sites located in this region (Castro et al. 1994, Llagostera 1996, Tarragó 2006, among others). Overall, the evidence indicates an extensive circulation of people and objects during pre-Columbian times in the Atacama Highlands, a phenomenon that can be dated as early as the Archaic period though it increased in importance during the last 3500 years in line with camelid domestication (Núñez 2006). As domestic South American camelids, llamas —*Lama glama*— have been proposed as one of the main vehicles for long-distance journeys within the pre-Columbian Andes because they can be used as beasts of burden (Browman 1980, Núñez and Dillehay 1979, Berenguer 1994, among others).

The main goal of this project is to thoroughly evaluate the participation of llamas as pack animals in the long-distance exchange journeys that connected the Atacama Highlands and neighboring areas —between 22° and 24° latitude S— between the Early Formative and Late periods —3500 years BP to the European arrival—. In order to do this, we will carefully examine the faunal record of different archaeological sites located within the current territories of Chile and Argentina as a way to establish the origin and mobility of those camelids possibly involved in long-distance trade. By focusing on the life history of the caravanners' animal companions, this project will address not only those aspects related to the character of the relationships that humans established with these animals but also explore different aspects of social interaction among the groups that inhabited the Atacama Highlands and adjacent areas during pre-Columbian times.

Justification for the research proposal

Caravan traffic can be defined as a specialized economic activity that involves long-distance transportation and the exchange of goods using trains of llamas as pack animals (Valenzuela et al. 2019). Traditionally, scholars studying long-distance exchange in the Andean Highlands placed a privileged role to this type of trade, drawing inspiration from several ethnographic accounts that highlighted the importance of llama caravans for historic and modern pastoralist communities (Browman 1984, Lecoq 1987, Nielsen 2001). However, despite the putative importance of caravans during pre-Columbian times, the use of llama trains as the main vehicle for long-distance exchange remains contested for most of the Andes with only a few exceptions (Briones et al. 2005, Pimentel et al. 2011). Some scholars have adopted an “internodal” approach to explore the archaeological record of the trade routes, focusing on the study of trails, shelters, campsites, and other signals left behind by travelers moving in between densely populated “nodes” (Berenguer 2004, Martel et al. 2017, Nielsen 2006, Pimentel et al. 2011). Although this approach can be useful to understand the circulation of certain items by linking them with specific routes, it cannot always distinguish specialized caravan trade from other kinds of trade —e.g. embedded

trade *sensu* Nielsen 2013— nor indicate the origin of the caravans that transited these routes (see Nielsen 2011 and 2013 for more details). This project proposes to tackle these questions through a broad-based approach by carrying out a systematic examination of the zooarchaeological record of the Atacama Highlands and neighboring areas in search of the bone remains of the llamas that were used as pack animals —*llamas cargueras*— in the past.

Research objective

The main goal of this project is to establish the participation of llama trains in pre-Columbian long-distance exchange journeys that connected the Atacama Highlands with neighboring areas, such as the Atacama Oases and the Quebrada de Humahuaca within the current territories of Chile and Argentina respectively. We aim to evaluate the existence of interaction mechanisms and long-distance trade practiced by the human groups that inhabited this area in the past by specifically addressing domestic camelid mobility employing zooarchaeological methods and radiogenic isotope analysis ($^{87}\text{Sr}/^{86}\text{Sr}$).

Methods

The project will combine zooarchaeology and strontium isotope analysis to explore domestic camelids' origin and long-distance mobility as a way to study caravan exchange in the Atacama Highlands and adjacent areas during pre-Columbian times. By combining these two lines of inquiry, this investigation will discuss the origin of the llamas employed in caravan trade as well as their movements over the landscape, paying special attention to the osteological indicators of stress linked to their use as pack animals (Cartajena et al. 2007, Labarca and Gallardo 2015, Yacobaccio et al. 2018) coupled with the use of the strontium isotope composition ($^{87}\text{Sr}/^{86}\text{Sr}$ values) of their tissues as a spatial proxy (Mader et al. 2018, Knudson et al. 2012, Thornton et al. 2011). Different sampling procedures for strontium analysis will be applied to different camelid tissues (bones and teeth) to provide complementary information about different moments of each camelid's life. Hopefully, this approach will contribute to identifying the participation of llamas as pack animals in caravan exchange journeys and the links with other archaeological findings that point towards the existence of long-distance trade networks in this region during Pre-Columbian times.

Work plan

The project can be divided into four non-consecutive research stages that comprise different activities, methods, and techniques.

Stage I involves the systematic examination of archives, collections, field notes, and any other previous archaeological evidence that points towards the existence of pre-Columbian long-distance exchange networks in the Atacama Highlands. During this stage, we will seek evidence such as the presence of certain marks across the landscape (rock art, trails, campsites, etc.) as well as foreign objects and resources (foreign pottery, lithic resources,

medicinal plants, etc.) in the archaeological record of the Atacama Highlands and adjacent areas within the current territories of Chile and Argentina.

Stage II comprises the zooarchaeological analysis of camelid remains recovered at different archaeological sites located in the Atacama Highlands and adjacent areas. During this stage, we will perform a detailed osteometric analysis to distinguish between wild and domestic camelids, followed by the close examination of those materials identified as llamas to establish the presence of bone pathologies and other osteological indicators of stress potentially linked to their use as pack animals in the past. The project will resume the findings of previous studies that identified the presence of such indicators in the faunal record of the area (Cartajena et al. 2007, Labarca and Gallardo 2015, Yacobaccio et al. 2018) and further explore its potential to address the use of llamas as beasts of burden during exchange journeys. This stage will comprise the analysis of camelid remains that are part of archaeological collections deposited at different museums and institutions in Chile and Argentina.

Stage III comprises the isotopic analysis of those materials identified as llamas during stage II. Particularly, we will use strontium isotope compositions ($^{87}\text{Sr}/^{86}\text{Sr}$ values) measured on llama tissues as an origin and mobility proxy. Broadly, the strontium isotope composition of an animal's tissues indicates the geologic region or regions in which the animal lived and fed during the formation of those tissues (Copeland et al. 2016). Hence, $^{87}\text{Sr}/^{86}\text{Sr}$ values will be measured on different llama tissues (bones and teeth) to explore life history changes. In this study, sequential analysis of tooth enamel will provide information about the llamas' origin and early years, as opposed to the time-averaged signal obtained through bulk bone analysis (Dufour et al. 2014). During this stage, bone and teeth samples from llamas recovered at archaeological sites will be selected and pre-treated before being shipped abroad for strontium isotope analysis.

Stage IV involves building a strontium isoscape to interpret the results obtained during stage III. An isoscape is a map of isotopic variation that operates as a spatially explicit predictive model for isotopic values across a landscape (West et al. 2010). In this case, it is necessary to elaborate a baseline for the interpretation of camelid $^{87}\text{Sr}/^{86}\text{Sr}$ values by establishing the local isotopic signal of bioavailable strontium for the different geologic regions covered here by measuring highly territorial animals —rodents— and plants (Hartman and Richards 2014). This information will be summarized into an isoscape by modeling its distribution using Geographic Information Systems (GIS) and will function as a tool to spatially predict future strontium isotope compositions (Bataille et al. 2020). This research stage will involve the collection of modern rodent bone and plant samples across the study area as well as the collection of rodent bone samples from existing archaeological and biological collections.

Qualifications of investigators and collaborators

As an archaeologist working in the Andean Highlands of South America, I was drawn to the study of prehistoric human subsistence strategies as well as camelid domestication and herding since the beginning of my career. During the development of my Ph.D. research at the University of Buenos Aires (2011-2015) and my Post-Doctoral research projects in Argentina (2016-2018), Germany (2018-2019), and Chile (2019-2021), I have employed different approaches to the study of human-camelid relationships in the Atacama

Highlands, mostly focusing on the application of zooarchaeological methods and stable isotope analysis to solve archaeological problems (Samec et al. 2014, Samec et al. 2020, among others). This experience has allowed me to evaluate phenomena such as camelid domestication and herding mobility from a new perspective that integrates both lines of evidence (Samec 2016). In this sense, the project proposed here represents a further development of my current post-doctoral project, which focuses on the study of herding mobility and its relationship with climate change during the Late Holocene in the Puna of Atacama.

Given the broad-based perspective of this project, it will involve the participation of a multidisciplinary team of researchers (archaeologists, anthropologists, and biologists) who will collaborate in different capacities. Hugo Yacobaccio is a Professor at the University of Buenos Aires and a senior researcher at the National Scientific and Technical Research Council (Argentina). He will contribute by offering his experience as a zooarchaeologist familiarized with camelid taxonomy and bone pathologies. Francisca Santana Sagredo is a physical anthropologist and a Professor at the Pontifical Catholic University of Chile (Chile). She will offer her experience evaluating past human mobility in Northern Chile. Ignacio Ferro is a biologist and works at the Faculty of Natural Sciences and Institute Miguel Lillo as an adjunct researcher of the National Scientific and Technical Research Council (Argentina). He specializes in rodent ecology and will contribute to the collection of modern rodent samples to build a strontium isoscape. Finally, Manuel López is a Professor at the National University of Cuyo and a post-doctoral researcher of the National Scientific and Technical Research Council (Argentina). He is a zooarchaeologist specialized in the analysis of rodent remains and will contribute to the project with his experience selecting rodent bones for isotope analysis.

Plans for the dissemination of results

My team and I will share the results of this project with colleagues and other potentially interested professionals by participating in scientific meetings and conferences where papers and posters describing the project outcomes will be presented. Moreover, the project results will be published in at least one scientific journal where the methods of the research will be discussed in detail. Additionally, we will develop outreach programs to bring the methodology and results of the project to the attention of different stakeholders, including local students, indigenous communities, and regional administrative institutions. Particularly, I plan to engage with local communities through the organization of workshops, talks, and other public events at schools and museums, as well as the elaboration of posters, leaflets, and other educational materials to be circulated among the community. Finally, the results of the project will be the subject of at least one podcast about long-distance caravan journeys and the circulation of certain objects within different localities of the Atacama Highlands and neighboring territories during Pre-Columbian times. This initiative seeks to reach a wider audience and to generate media content that could be used by local authorities and public institutions (schools, museums, etc.) for educational purposes in the future.

5. PERMITS

The permits and approvals required to conduct this project are:

- Permit granting access to collections and archives deposited at the Instituto de Investigaciones Antropológicas y Museo R. P. Gustavo Le Paige S.J. (San Pedro de Atacama, Chile)
- Permit granting access to collections and archives deposited at the Instituto Interdisciplinario Tilcara (Tilcara, Argentina)
- Permit granting access to collections and archives deposited at the Instituto de Arqueología (Buenos Aires, Argentina)

Only when archaeological samples have been selected and are ready to be shipped abroad, the following permits will be necessary:

- Authorization from the Consejo de Monumentos Nacionales de Chile
- Authorization from the Registro Nacional de Yacimientos, Colecciones y Objetos Arqueológicos de Argentina

It is worth mentioning that permits to access the collections deposited at the Instituto de Investigaciones Antropológicas y Museo R. P. Gustavo Le Paige S.J. (Chile) and the Instituto de Arqueología (Argentina) were already granted to the project leader regarding an on-going project. We expect to obtain access to the collections deposited at the Instituto Interdisciplinario Tilcara by mid-2021.

6. SCHEDULE

The proposed project contemplates the following timeline covering all four research stages outlined before:

2021. May-July: Activities listed in stage one.
Preexisting data analysis (collections, archives, and field notes).

2021. August-October: Activities listed in stages two, three, and four.
First field season (Chile). Collection of modern samples (rodents and plants for strontium isotope analysis to build the isoscape).
Examination and sampling of bone remains within collections located at local museums and institutions (San Pedro de Atacama, Chile).

2021. October-December: Activities listed in stages two, three, and four.
Second field season (Argentina). Collection of modern samples (rodents and plants for strontium isotope analysis to build the isoscape).
Examination and sampling of bone remains within collections located at local museums and institutions (Tilcara, Argentina).

2022. January-March: Activities listed in stages two, three, and four.
Examination and sampling of bone remains within collections located at urban museums and institutions (Buenos Aires, Argentina).

2022. April: Elaboration of final report and project outputs.

2) Reformulation of work schedule due to covid-19 related uncertainties

New starting date: 11/05/2021

New end date: 11/04/2022

The project contemplates the following timeline covering the four research stages outlined in the original proposal:

2021-2022. November-February: Activities listed in stage one.
Preexisting data analysis (collections, archives, and field notes).

2022. March-April: Activities listed in stages two, three, and four.
First field season (Argentina). Collection of modern samples (rodents and plants for strontium isotope analysis to build the isoscape).
Examination and sampling of bone remains within collections located at local museums and institutions (Tilcara, Argentina).

2022. May-July: Activities listed in stages two, three, and four.
Examination and sampling of bone remains within collections located at urban museums and institutions (Buenos Aires, Argentina).

2022. August-September: Activities listed in stages two, three, and four.
Second field season (Chile). Collection of modern samples (rodents and plants for strontium isotope analysis to build the isoscape).
Examination and sampling of bone remains within collections located at local museums and institutions (San Pedro de Atacama, Chile).

2022. October-November: Elaboration of final report and project outputs.

7. LOCATION AND FIGURES

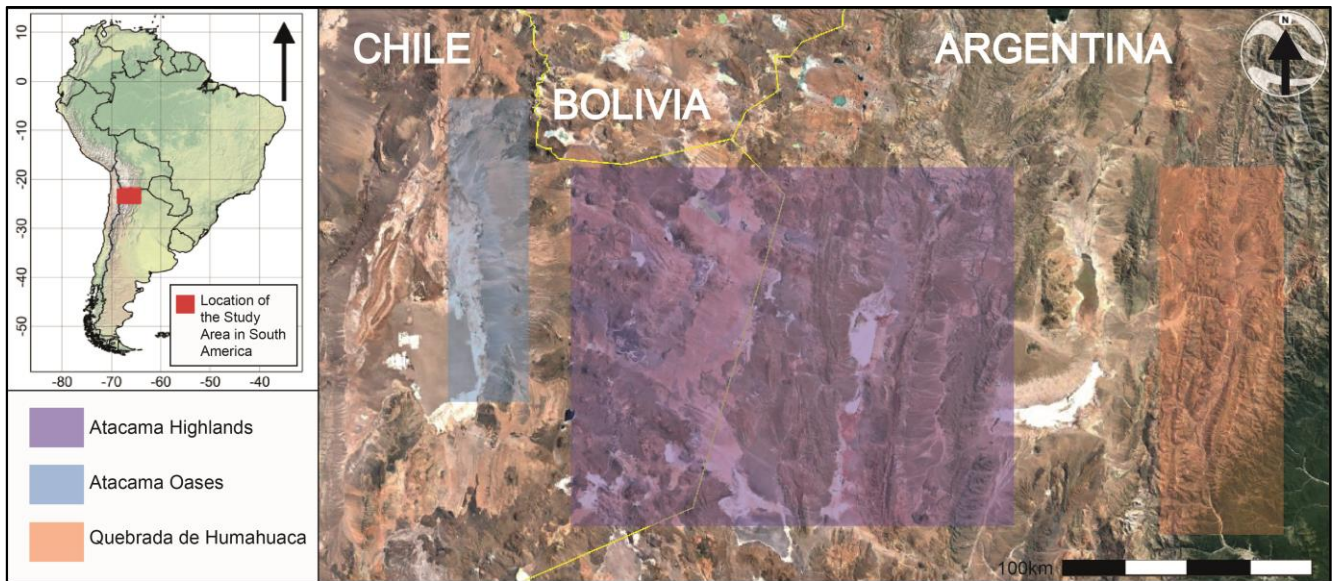


Figure 1. Map of the study area showing the Atacama Highlands (covering the current territories of Chile and Argentina) and adjacent relevant areas such as the Atacama Oases (Chile) and the Quebrada de Humahuaca (Argentina).

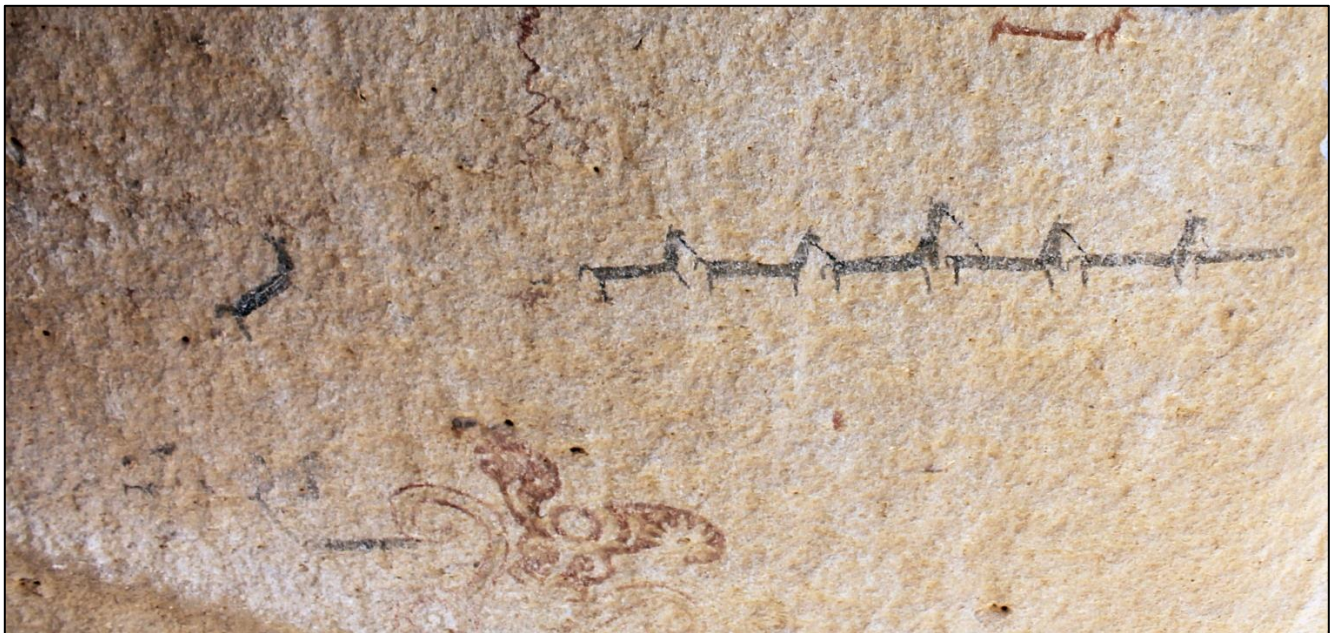


Figure 2. Rock art motive that showing a llama caravan (Cueva del Caravanero archaeological site, Jujuy, Argentina) (Photo Hugo Yacobaccio).



Figure 3. Modern llama caravan outside the town of Santa Catalina (Jujuy, Argentina)
(Photo Hugo Yacobaccio).

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9. PUBLICATIONS AND OUTPUTS

Among the different expected outputs of this project, we can list both academic and non-academic products.

Among the academic outputs, we expect to produce at least one (1) publication as well as one (1) meeting presentation and one (1) map. In the first case, the results achieved by this project will be included in at least one scientific publication where the phenomena of pre-Columbian long-distance caravan exchange in the Atacama Highlands and neighboring areas will be extensively discussed. At the same time, the innovative methods used in this project will be presented in at least one conference or scientific meeting where the implications of the combined use of zooarchaeological and isotope analysis to the study of Pre-Columbian long-distance caravan exchange will be discussed with colleagues and other professionals. On the other hand, we believe that the results of this project will contribute to the creation of a map where relevant archaeological sites and possible pre-Columbian long-distance caravan exchange routes will be presented. Finally, it is worth mentioning that the results of the project will contribute to the elaboration of a strontium isoscape for the study area that will be useful for the development of future research projects about animal and human mobility.

Among the educational and science outreach outcomes that we expect to produce at the end of this project, we can list the elaboration of at least one (1) poster, the organization of one (1) workshop, and the production of one (1) podcast. First, as a part of the development of a broad outreach program designed to bring the results of the project to the attention of local communities, we plan to elaborate posters and other educational materials to distribute among public local institutions such as schools and museums. Also, we plan to organize at least one workshop to bring the methodology and results of the project to the attention of different stakeholders, including local authorities, indigenous communities, and regional administrative institutions. Finally, the results of the project will be the subject of at least one podcast about long-distance caravan journeys and the circulation of foreign objects within different localities of the Atacama Highlands and neighboring territories during Pre-Columbian times.