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A BIT CLOSER TO THE PAST: THE THREE-DIMENSIONALIZATION OF AN INCA CEREMONY IN THE NORTH CALCHAQUÍ VALLEY (SALTA, ARGENTINA)

UN BIT MÁS CERCA DEL PASADO: LA TRIDIMENSIONALIZACIÓN DE UNA CEREMONIA INCA EN EL VALLE CALCHAQUÍ NORTE (SALTA, ARGENTINA)

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Highlights:

- Inca public performances were finely choreographed so that objects, places, people, landscape, and skyscape features interacted according to the main principles of imperial cosmology.
- Current mid-range hardware and specialized yet reasonably user-friendly software is suitable to create accurate three-dimensional (3D) models combining historical, archaeological, and astronomical data.
- Creating such a detailed 3D model contributes to cultural heritage and academic dissemination and prompted us to revise and broaden our interpretations.

Abstract:

Like other expansive polities, the expansion of the Inca empire across the highlands and lowlands of South America is not only a history of trade and warfare, but also of mesmerizing public performances that yielded new and memorable experiences. During highly ritualized public celebratory events, the local polities gained first-hand access to the imperial liturgy, which was vital to promote and legitimate the Inca cosmology across the newly acquired lands. Especially in the last 20 years, new technologies, an ever-growing corpus of archaeological data, as well as increasing hardware capacity and software development, make it possible to emulate the scenes that people got to witness during the Inca public events, at a home computer scale and without complex and expensive equipment. Furthermore, it prompts us to test and apply new tools and academic dissemination techniques, perhaps more suitable to current technologies and means of knowledge storage and circulation. This article presents the process of building a three-dimensional (3D) model that, on the one hand, combines historical, ethnographic, and archaeological data with Geographic Information System (GIS) datasets; on the other hand, it uses detailed architectural analysis and astronomical measurements. The objective is to yield renders that accurately display the atmospheric and lighting conditions prevailing when the site was inhabited. We will offer a detailed description of all methods, techniques, equipment, and software used to create the model and the parameters for rendering the images. The authors intend to exemplify how 3D modelling goes well beyond the 3D model as a product in itself; it becomes a fundamental tool that encouraged us to test new variables and discuss new interpretations about this settlement. Results indicate that its builders designed these settlement's Inca compounds to show off the imperial capabilities and constructive proficiency, to convey exceptional, memorable experiences to its residents and visitors, and to stage explicit links between the imperial representatives and some fundamental procreative components of the Andean cosmos. In doing so, Guitián's plaza served to stage and communicate the privileged role the imperial representatives claimed to have in a broader cosmological scheme.

Keywords: Inca public ceremonies; 3D modelling tools and techniques; archaeological interpretation; cultural heritage; academic dissemination

Resumen:

Al igual que otras políticas expansivas, la expansión del imperio Inca a través de las tierras altas y bajas de Sudamérica, además de ser una historia de comercio y conflictos armados, lo es también de espectáculos públicos cautivantes que introdujeron experiencias nuevas y memorables. Durante celebraciones públicas altamente ritualizadas, las autoridades locales tuvieron acceso de primera mano a la liturgia imperial, lo que fue vital para promover y legitimar la cosmología Inca en los territorios anexados. En los últimos 20 años en particular, las nuevas tecnologías, un corpus cada vez mayor de datos arqueológicos, y el aumento de la capacidad de hardware y el desarrollo de software hacen posible emular las escenas que la gente presenció durante las ceremonias públicas Inca; ello es posible sin equipos complejos y costosos (basta con un ordenador doméstico). Todo ello nos impulsa a probar y aplicar nuevas herramientas y técnicas de

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difusión académica, quizás más adecuadas a las tecnologías y medios actuales de almacenamiento y circulación del conocimiento. Este artículo presenta el proceso de construcción de un modelo tridimensional (3D) que combina datos históricos, etnográficos y arqueológicos con conjuntos de datos en Sistemas de Información Geográfica (SIG), análisis arquitectónicos detallados y mediciones astronómicas; todo ello tiene el objetivo de lograr renders que contemplen adecuadamente las condiciones atmosféricas y de iluminación que prevalecían cuando el sitio estaba habitado. Se ofrecerán detalles completos de todos los métodos, técnicas, equipos y programas informáticos utilizados para crear dicho modelo y los parámetros de renderización de las imágenes que presentaremos. Este estudio ejemplifica cómo el modelado 3D va mucho más allá del modelo final como producto en sí mismo: se convierte en parte fundamental de un proceso interpretativo que nos obligó a probar nuevas variables y discutir nuevas interpretaciones. Los resultados indican que los constructores de los recintos Inca de este asentamiento lo hicieron tanto para ostentar su destreza constructiva, destacarse en el paisaje local, transmitir experiencias excepcionales y memorables a sus residentes y visitantes, como para escenificar vínculos explícitos entre los representantes imperiales y algunos componentes procreativos fundamentales del cosmos andino. Consecuentemente, la plaza de Guitián servía para escenificar y comunicar el papel privilegiado de los representantes imperiales en un esquema cosmológico más amplio.

Palabras clave: ceremonia pública Inca**;** técnicas y herramientas de modelado 3D; interpretación arqueológica; patrimonio cultural; difusión

1. Introduction

The Inca Empire, known as *Tawantinsuyu*, managed to integrate a wide array of indigenous polities and administrate millions of km^2 throughout the highlands, coasts, deserts, and jungles from Ecuador, Perú, Bolivia, Argentina, and Chile by 1532 AD, about one century after the foundation of the imperial capital (Cusco, Perú). Inca expansionism success is undisputable. Aided by a complex road network estimated at 40000 km in length, the Incas connected a wide variety of ecological floors where they built administrative centres, productive enclaves, fortresses, staging posts, ceremonial centres, and high-altitude shrines.

Scholars of *Tawantinsuyu* have established that the imperial performances during hospitality feasts and public ceremonies were central elements in Inca colonial policies (Bauer, 1996; Bray, 2003; Coben, 2006, 2012; Moore, 1996; Makowski, Córdova, Habetler, & Lazárraga 2005, among many others). Through massively concurred and highly ritualized public celebratory events (as well as pilgrimages to sacred sites), the imperial representatives engaged local people and authorities to convey a new cosmological order wherever they went (Acuto, 2012; Arkush, 2005; Bauer & Stanish, 2001; Chávez Justo & Stanish, 2012; Dean, 2010: 109; Kosiba, 2012; Stanish & Bauer, 2007). Usually, the Inca authorities convened selected groups from local populations, some of which made long trips to attend and have a first-hand experience of the imperial liturgy. Such liturgy portrayed the Incas as entities that were especially capable of establishing a privileged connection to the Andean cosmos' non-human entities and forces and crucial to legitimate and promote the Inca domain over the Andes.

Given that what local people got to witness during ceremonial events was key to the promotion and legitimation of the imperial cosmology, how do we get closer to the experience of participating in an Inca festivity? What can we do to get closer to what people experienced when they visited these sites?

Especially in the last 20 years, archaeologists have advanced towards new methods and techniques in order to understand and explore other(s) sensoria and neutralize or defy some inherent “western” biases. Interdisciplinary teams all over the world began to focus on subjects such as the evocative capacity of touch and textures (e.g., Cummings, 2002;), smells and tastes (Fahlander, 2010; Hamilakis, 1999; Price, 2018), and sound (Ferrari, Leibowicz, Izaguirre & Acuto 2017a; Izaguirre & Ferrari, 2018; Primeau & Witt, 2018; Watson & Keating, 1999, among many others).

Since Reilly's pioneering work in the late 1980s (see Reilly, 1988; Reilly & Shennan 1989), the use three-dimensional (3D) modelling aided archaeologists in the protection and conservation of heritage assets (e.g., Frischer, 2005), recording of archaeological sites and artefacts (e.g., Allen et al., 2004), education and heritage learning (e.g., Rascón Marqués & Sánchez Montes, 2008; Sanders, 1999), and the analysis of the present (e.g, Forensic Architecture research agency) and the past (e.g. Karasik, 2008). The usage of 3D models progressed rapidly. Virtual reality, mixed reality, augmented reality, and virtual anastylosis became common themes in archaeology, museology, and heritage. What began as a few isolated cases that prioritized documentation and exhibition, rapidly evolved into international networks dedicated to link research centres[1] and establishing procedural and ethical standards for the creation and use of 3D models (e.g., Seville Principles and The London Charter).

In the last two decades, certain advances in technology (especially the increasing processing capacity of home computers) have favoured the development, distribution, availability, and ease of usage of customer-friendly software capable of calculating complex phenomena. Archaeology has taken advantage of the so-called new technologies and oriented them mainly towards three areas of archaeological practice: object digitisation and the documentation of archaeological excavations (e.g., Gil-Melitón & Lerma, 2019; Previtali & Valente, 2019), the analysis of visual and acoustic experiences (e.g., Falconer et al., 2020), and the exhibition and dissemination of archaeological interpretations (e.g., Flores Gutiérrez et al., 2011) with novel devices and methods (e.g., virtual reality and augmented reality), all of them favouring the protection of cultural heritage.

Of course, 3D reconstructions have an apparent educational and explanatory power (Hwang, Huang, & Dong, 2009). They can bring us closer to the scenes and images that shaped peoples' experiences and memories

[1] Virtual World Heritage Laboratory (VWHL), the *Sociedad Española de Arqueología Virtual* (SEAV), the Virtual Archaeology International Network (INNOVA), the Ename Center for Public Archaeology and Heritage Presentation, and the Center for Documentation of Cultural and Natural Heritage (CULTNAT), to mention just a few.

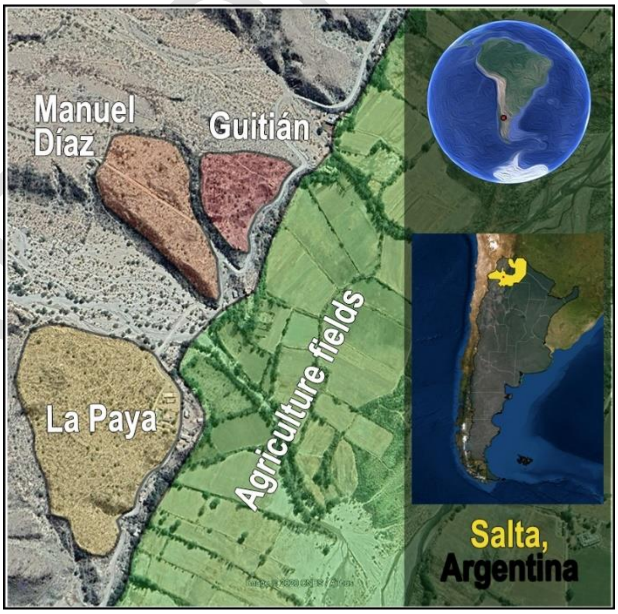
and become a powerful tool to understand and value cultural heritage (Rascón Marqués & Sánchez Montes, 2008: 92).

In this article, we seek to present and discuss one way of getting closer to understand and to share and communicate what could have been the experience of attending a ceremony at an Inca central square (or '*plaza*') during the 15th century. To do so, we combined historical, ethnographic, and archaeological data to create a detailed 3D model of an archaeological settlement known as Guitián (north Calchaquí Valley, Salta, Argentina). Such model includes the three-dimensionalization of a digital elevation model (DEM) of the surrounding landscape, the atmospheric and lighting conditions prevailing when the site was inhabited, "rock by rock" details of the walls of the enclosures, and, of course, people. We will offer a detailed account of all methods, techniques, equipment, and software used to recreate Guitián's ancient atmosphere. We will detail every step we took to build the 3D model, create the textures, and the rendering engine, parameters (target quality in dB[2] and iterations) and elapsed time. Finally, we will show how this process compelled us to discuss new interpretations and add new variables that might have been determinant for people's experience when they approached and entered the Inca *plaza* to participate in an imperial public ceremony.

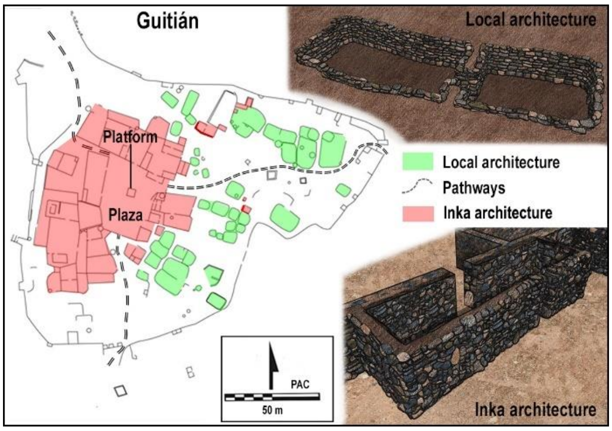
2. Guitián

Several Inca architectural enclosures and settlements in the north Calchaquí Valley had received substantially more attention than Guitián and have been more intensively surveyed during the 20th century (Acuto, 2004; Acuto & Gifford, 2007; Ambrosetti, 1907; Difrieri, 1948; Williams & D'Altroy, 1998). Serious systematic research in Guitián (SSalCac 2, 25°11'06.05''S, 66°11'30.17''W, 2288 m ASL) began towards the mid-1990s. An interdisciplinary team led by North American and Argentinean researchers (respectively Terence D'Altroy and Verónica Williams) made the first descriptions and the first detailed floorplan. After a brief hiatus, research resumed in 2007 and continues to this day (see Acuto, 2010; Acuto 2012; Acuto, Troncoso & Ferrari, 2012; Ferrari, Leibowicz, Izaguirre & Acuto, 2017a; Ferrari, Acuto, Izaguirre, & Jacob, 2017b). Current archaeological surveys include surface collections, excavations, intensive material analysis seasons, and a constant articulation of these activities with the local indigenous communities. Non-archaeological activities include conference talks with indigenous authorities, school teachers and students, the production of educational posters and banners, the sharing of research results through adapted versions of academic articles and theses, and repeated trips to archaeological sites with any interested member of the local community. This recent but continuous process in the north Calchaquí Valley even led to a joint knowledge production between researchers and local indigenous communities' members (e.g., Acuto & Corimayo, 2018; Corimayo & Acuto, 2015; Flores & Acuto, 2015).

A simple look at Guitián's layout easily allows us to differentiate a local and an Inca area (Fig. 1). The Inca area articulates around a large open space (a *plaza).* This *plaza* connects to other residential and ceremonial Inca complexes through narrow accesses. Towards the *plaza*'s centre, there is a ceremonial platform. Such ceremonial platforms (commonly called *ushnu*) have been usually described as seats or stages from which the Inca and his retinue would address public ceremonies' attendees. Nevertheless, this was not their only purpose. These platforms usually had devices (such as bowls, wells, and monoliths) through which Inca ritual specialists connected with the non-human realms and their sacred entities and channelled their procreative forces towards the realm inhabited by people, their animals, and their crops (Meddens, 1997, 2015; Meddens, Branch, Pomacanchari, Riddiford, Kemp, 2008; Monteverde Sotil, 2010; Pino Matos, 2005; Staller 2008; Zuidema, 1980).



(a)



(b)

Figure 1: a) Location of Guitián and nearby sites; b) Guitián's layout and typical local and Inca style architecture at the settlement.

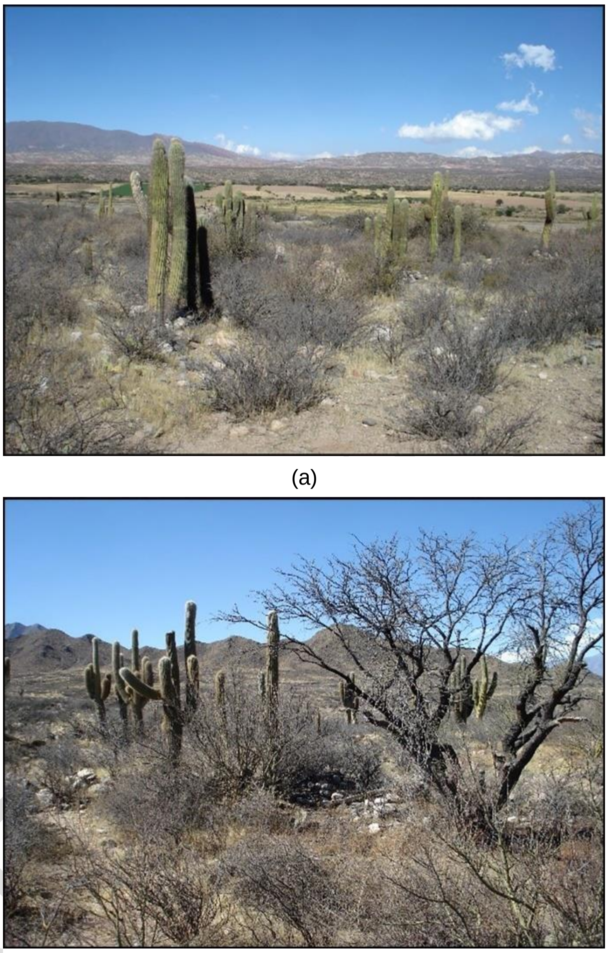
[2] As defined by Mustafa et al. 2017, *"SNR is defined as the ratio of the average signal value to the standard deviation of the signal value. Higher SNR value showed a better quality image and low SNR indicates the certain region of image weakness relative to background noise"*. Autodesk developers synthesize it the following way: "*Rendering quality is measured as the signal to noise ratio (SNR) in decibels (dB)*".

The local architecture area consists of subsurface residential compounds distributed across the settlement's eastern sector in sets of a few structures, with only some showing mild traces of foreign interventions. Local pre-Inca compounds were partially excavated in the substratum and then coated with local unmodified boulders and pebbles settled with mud and fine gravel and river stones. Occupation levels are currently buried between 1 and 1.4 m below the actual surface. Typical local compounds are usually identifiable on the surface by the perimeter drawn by the first (or uppermost) line(s) of wall rocks and a slight depression towards the middle of the building. There are examples of local non-subsurface pre-Inca constructions, but not at this or neighbouring sites. Excavations in the eastern local compounds of Guitián corroborate that this was the dominant technique at this settlement. There are no straight connections between any of these local compounds and the *plaza*, but there is a clear pathway that enters the site, runs between them, and reaches narrow access (0.6 m) in its northeastern corner. The other two pathways that reach the *plaza* connected its southern and northwestern accesses with entrances in the settlement's perimetral wall. How, when, and who could have walked these pathways are some of the issues that we will address in this article once we discuss how people could have experienced reaching the Inca *plaza*. An overview of Guitián's layout not only makes it clear that the ceremonial life orbited around the *plaza* but also suggests that sponsoring public ceremonies was its primary purpose.

In the past, we had built 3D models of this site almost exclusively to test the plausibility of visibility hypotheses and run sound dispersion models (e.g., Ferrari et al., 2017a). However, Guitián faces other, more urgent problems. Sadly, this site has suffered (and still does) from processes that deteriorate it daily and make it increasingly difficult to identify its architectural features (Fig. 2). Among the environmental factors that contribute to the site's deterioration stand out: animal activity (particularly wild donkeys and rodent nesting), plant activity (mainly the destruction of walls by the growth and fall of dry cardones (*Trichocereus pasacana*), and deterioration of walls fillings and rock coated surfaces due to heavy seasonal rains. Among the human factors, especially modern ones, the most serious are rocks removals to build modern houses and the reconstruction or adaptation of some structures to use them as corrals. The site is also on a regular grazing route, and it is common to detect tracks that sometimes cross structures through collapsed wall segments. Unsupervised tourism has had almost no impact on its preservation, but Guitián has also suffered looting.

Due to these circumstances, we created a 3D database that we constantly update with new architectural analyses and excavations. The final goal is to make this data available to the non-archaeological public, mainly (but not limited to) local indigenous communities. Actual ongoing projects around this and other sites in the northern Calchaquí valley include further analyses of the acoustic properties of local and Inca architecture, sound dispersion models, hyper-realistic 3D models, video games, augmented reality, and mobile applications (Acuto, 2018; Ferrari, 2020-23; Izaguirre, 2020-23).

Next, we will first detail the methods, techniques, equipment, software, tools, historical and archaeological data used to build a 3D model of Guitián. Then, we discuss the scenes that people might have been exposed to when entering Guitián, walking towards the *plaza*, and participating in a ceremony. Finally, we discuss how building this model compelled us to enrich our interpretations of this settlement and propose new interpretations.



(a)

(b)

Figure 2: Settlement's vegetation and current state of preservation: a) View from the *plaza* towards the northeast; and b) towards the northwest.

3. Building the model: illumination, texturing, and archaeological data.

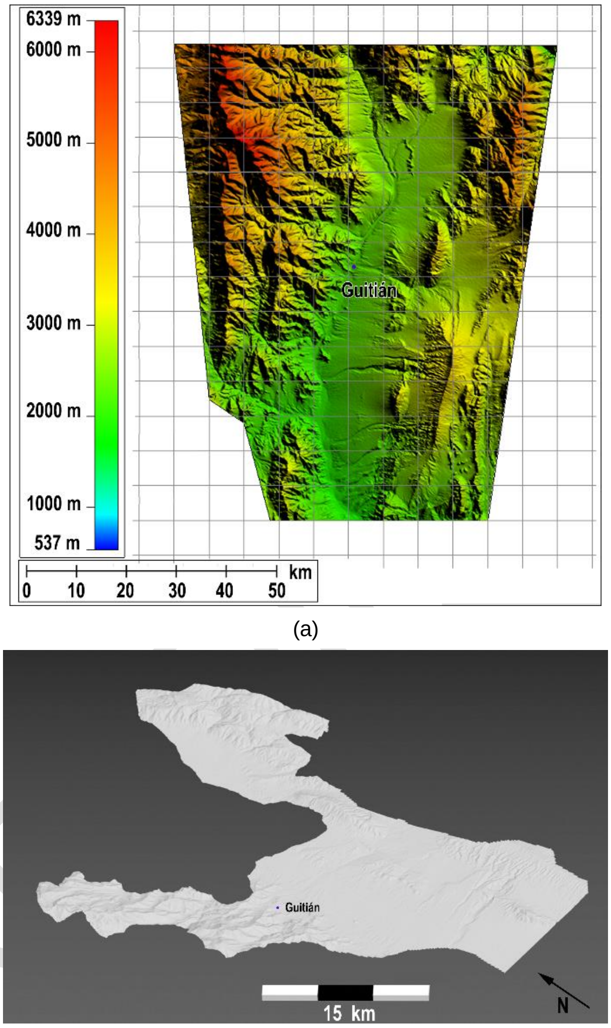
Archaeological fieldwork and lab analysis since 2007 allowed us to generate reliable data regarding the architecture and the activities in the public square and the local and Inca domestic compounds. These works consisted of surface collections, architectural surveys, minor changes to the original planimetry, and archaeological excavations in local and Inca domestic compounds, the *plaza*, and the platform. Below, we will start with some general decisions regarding the geographical setting, atmospheric conditions, lightning, and the surrounding landscape. Afterwards, we will get to the specifics of modelling the buildings and enclosures and the rendering parameters that we used.

3.1. Illumination

Lighting is one of the essential conditions of any 3D model. It draws the line between a relatively flat representation and a realistic image. Accurate lighting is a must in a 3D model of an archaeological site like Guitián. Illumination was frequently taken into account by the imperial architects to design their villages and towns. Accesses, monoliths, columns, rock piles, and landscape features helped specialists observe changes in the sun's path and other celestial bodies' positioning, hence predicting the most important seasonal changes (e.g., solstices and equinoxes) and organizing the ritual and agricultural calendar (Bauer & Dearborn, 1995; Decoster, 1997; Garcilaso de la Vega, 1985; Moyano, 2013; Sanhueza, 2017; Zuidema, 1977). We also know that the Incas chose the times for some of the most important ceremonies very carefully. Sunrises and sunsets were preferred since they are considered transitional moments intimately related to the behaviour of a fundamental non-human entity of the Inca cosmology: *Inti* (the sun).

To refine the Guitián model's illumination, we had to adjust it to the lighting conditions that may have taken place when it was inhabited and at specific times of the year and moments of the day. To fulfil this goal, we generated the illumination following the sun's position during the solstices and equinoxes, respecting how it leaked through accesses and mountain passes and how it bounced off the surrounding hills and the buildings of the settlement. To adequately model the horizon, we used a satellite image provided by the Shuttle Radar Topography Mission (SRTM) and processed in 2014 by the National Geospatial-Intelligence Agency (NGA) and National Aeronautics and Space Administration (NASA). We selected an area of 67 x 49 km and used Autodesk Civil 3D software *to create the Surface from the DEM* tool) to process the satellite image and generate a triangulated irregular network (TIN). Both 3D models -the reconstructed site and the terrain- were combined into a single model suitable for processing with Stellarium v. 0.20.4 first and by 3D Studio Max 2020 for realistic lighting creation and refinement. To reduce the processing burden due to excessive polygons, we gradually eliminated those areas that should not have been visible according to our final model, so that the final terrain model becomes easily manageable (Fig. 3). Due to our model's scale, we could not match it directly with the sun's position without adjustments to mimic the earth's curvature. As noted by Zotti & Neubauer (2019: 99), in horizons that exceed a few hundred meters, due to the "flat earth" approximation used by the Stellarium, there could be misleading azimuth and altitude measurements. In our model, the distance between the ceremonial platform in the centre of the *plaza* and the summits of the Nevado de Cachi mountain range is 30 km. We chose this natural feature because we had altitude and azimuth on field measurements of the summits Meléndez, Peñón Blanco, and Hoygaard from the centre of the *ushnu* platform (Moyano 2013), which we were able to compare with measurements obtained exclusively through the Stellarium ported model without curvature adjustments (Tables 1 and 2).

Finally, we projected the earth's curvature into our 3D Autodesk 3D Studio Max model to curve the terrain. To simplify the projection, we treated the earth as a sphere with a radius of 6371 km. We calculated the amount of deformation using the following formula: $\sqrt{re^{\wedge}2 - d^{\wedge}2} - re$, where re is equivalent to a standardized radius of the earth (6371 km) and d is equivalent to the distance until the farthest object in the horizon in the x and y axes from the centre of the polygon (33.5 km and 49.5 km, respectively). We applied the 3D Studio Max's *bend modifier,* capable of curving a plane-based surface along any user-defined axis to transfer this curvature to our model. Our model needed a 0.67° curving along a north-south axis and a 0.49º curving along an east-west axis to input the earth's curvature and considerably reduce the difference between the 3D model and fieldwork measurements.



(a)

(b)

Figure 3: Guitián's surrounding topography: a) SRTM image; and b) cropped perspective view of the TIN.

Table 1: Non-adjusted field vs. Stellarium measurements (sexagesimal degrees, WGS 84 datum)

Feature	*Field measurement*	*Stellarium measurement*	*Error*
Meléndez	325°37'59" 7°09'21.11"	325°34'37.7" 7°23'25.9"	0°3'21" 0°14'5"
Peñón Blanco	323°30'59" 7°19'28.72"	323°26' 54.4" 7°28'10.2"	0°4'5" 0°8'41"
Hoygaard	329°40'59" 6°38'58.26"	329°26'19.6" 6°53'37.1"	0°14'42" 0°14'39"

Table 2: Field vs. Stellarium measurements after curvature adjustments (sexagesimal degrees, WGS 84 datum)

Feature	*Field measurement*	*Stellarium measurement*	*Error*
Meléndez	325°37’59” 7°09’21.11”	325°37’51 07°17’12.7”	0°0’8” 0°7’52”
Peñón Blanco	323°30’59” 7°19’28.72”	323°28’21.9” 7°24’01.8”	0°2’37” 0°4’33”
Hoygaard	329°40’59” 6°38’58.26”	329°33’57.9 6°49’06.8	0° 7’ 1” 0°10’8”

We incorporated the resulting model into Stellarium according to their procedure guide (Zotti & Wolf, 2020). To calculate the position of the sun at solstices and equinoxes, we used 1430 AD as a reference, which is close to the earliest date for an Inca context in Guitián (the deposits in the *ushnu* platform) and keeps correspondence with the other dates of the Inca occupation in nearby sites (Amuedo, Ferrari, Acuto, & Lema, 2020; D’Altroy et al., 2000; Ferrari, 2019; Ferrari et al., 2021). We obtained/generated a detailed record of the sun's position throughout the day (once every 20 minutes), complemented with recordings during the sunset and the sunrise (once every minute).

Achieving a high degree of illumination realism in a 3D model depends heavily on two variables: the type of lighting used and the lighting engine. To replicate the illumination in Autodesk 3D Studio Max, we used the sun positioner lighting system, which allowed us to emulate natural lighting just by entering the coordinates of the azimuth and the altitude of the sun. We entered the sun's coordinates every 20 frames, generating a simple animation that reproduces its movement during sunrise and sunset. This technique makes it easier to identify the illumination phenomena that the settlement's layout could have promoted and to follow the changing spotlights and shadows through a chosen period/interval of time. To render the illumination, we used the default lighting engine of 3D Studio Max (ART-Render). This tool proved to be capable of offering accurate results with moderate processing hardware demands, since we created the model and rendered every figure with an I7 3770 ivy bridge CPU, 32 GB RAM, and a GeForce 1060 with 3GB VRam GPU. To better test the contrasts between light and shadows, we processed the illumination animations without textures, which considerably reduced the rendering times during the initial tests, further data acquisition, and calibration and adjustments stages. Each sun cycle animation encompassed between 600 and 800 frames, depending on the number of hours the sun was on the visible horizon (Fig. 4).

3.2. Texturing

Our architectural analysis, the photographs of the standing walls, and the excavation records offer us a clear idea of native and Inca construction techniques (including rock positioning, relief, orientations, selection, and colouring). To build the textures for our model, we processed the photographs to create bump and displacement maps (Fig. 5A, B, C, D).

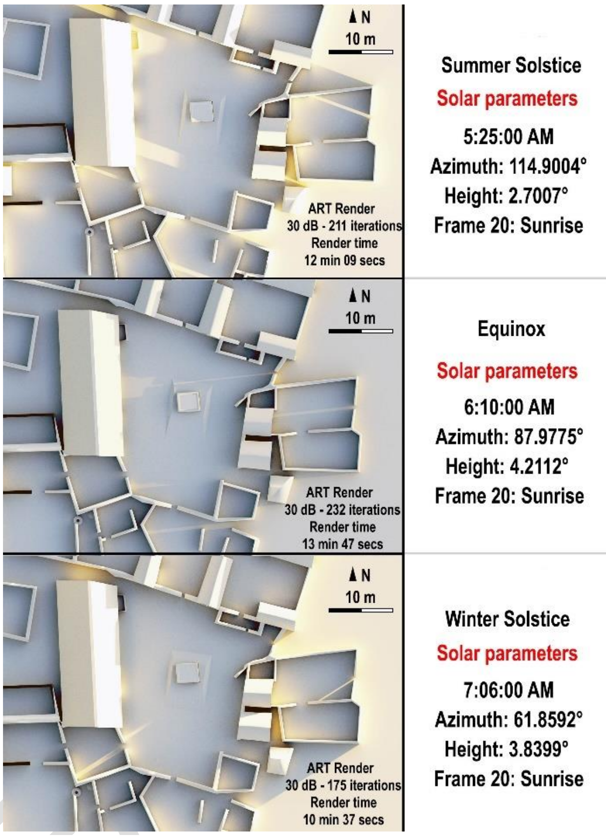


Figure 4: Sample lighting in the *plaza* and surrounding compounds during solstice and equinox dates.

In the past, we applied a different technique to build walls’ textures. It consisted of creating a layer of high contrast black and white images on which we applied a bump modifier that helped us emulate the masonry's relief. This technique has proven to be useful for animations and less laborious and faster processing, but it fails to provide the resolution and the fidelity we are trying to achieve now.

Over time we have used different types of cameras during the surveys. To create the textures that we are using for this model, we have used really modest cameras: a digital single-lens reflex (DSLR) camera Nikon D3200 with the lens set at 50 mm and a standard digital Sony DSC-W70 with a focal length of 18 mm. In this last case, we took the photographs close enough so that the deformation that such a wide-angle creates towards the edges became barely noticeable.

To create the dome portraying the horizon maps, we used a series of panoramic photographs taken from the centre of the ceremonial platform with a tripod that has a built-in water level and an angle dial. The resulting 360º panoramic images were created with Adobe Photoshop CC 2019 and checked against the 3D model built upon the DEM (Fig. 5E).

Character texturing presents a different challenge, especially when it comes to clothing. We know that textile usage and production in the Andes are far from being a mere utilitarian activity (Arnold, 2018; Franquemont et al., 1992; Murra 1962). Clothing was one of the many ways in which people accredited their status, their ethnic affiliation, and provincial provenance under the Inca administration (Anónimo, 1879: 200; Molina, 1964: 36; Santa Cruz Pachacuti, 1964: 245-246)

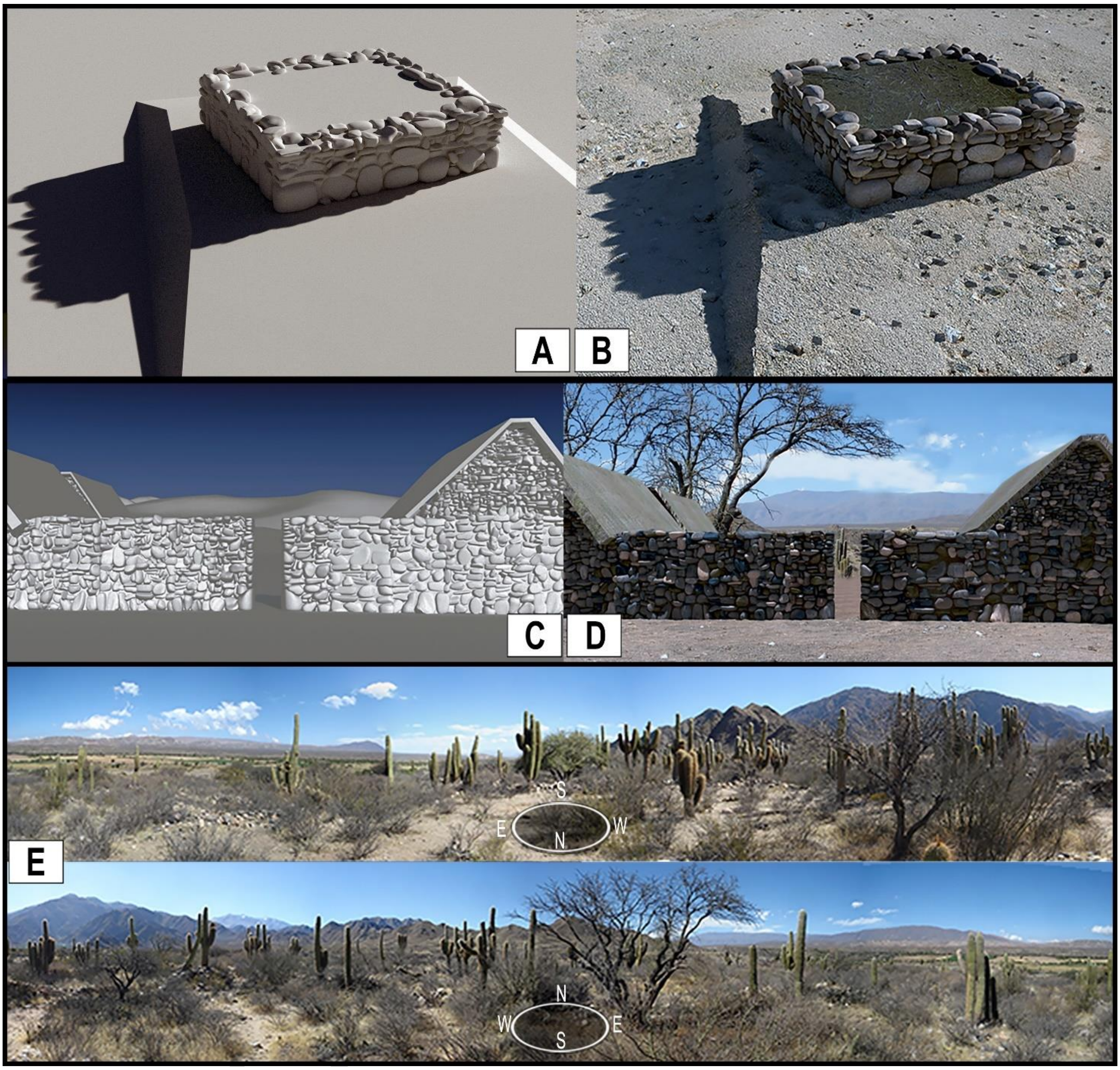


Figure 5: Walls' and horizon's textures: (A & C) 3D base textures, (B & D) supplementary textures, and (E) 360º panoramic images.

and its forgery or misrepresentation was often a reason for sanctioning (Cobo, 1892: 240-241). Specific garments were selected and produced as offerings in different ceremonies. Some events demanded the use of textiles reserved for these special occasions and made of delicate fabrics with specific colours, ornaments, and designs that distinguished from the daily use (Arriaga, 1621: 44-45; Cobo, 1892: 34, 286; Molina, 1964: 70, 82-83). The chronicler Betanzos (1992: 97-98) points out the use of gold and silver weaved T-shirts with litmus feathers during December, while during May to June, noble groups wore long red T-shirts that reached their feet. Some buildings (such as *ushnu* platforms) and sacred features of particular importance were also dressed or covered with specific textiles, but whether such a thing occurred in Guitián is something we might never be able to determine with certainty.

Dressing people included in the model was challenging. First, textiles degrade easier than other materials that archaeologists work with regularly, and we have not recovered any from the excavations in this settlement yet. Secondly, there is a relative scarcity of documentary sources and archaeological evidence for textiles in northwestern Argentina. Notable exceptions come from some of the most important archaeological sites in Northwestern Argentina, such as Casabindo, Angualasto, Doncellas, Tastil, Tilcara, and Llullaillaco (Pérez de Micou, 1997; Reinhard, 1993; Reinhard & Ceruti, 2000; Renard, 1994, 1997). Third, when we take all the documentary sources and archaeological evidence altogether, there is great variability regarding clothing types and their design following many different ethnic groups. A characterization of this variability can be found in the very well-known motifs portrayed by Guamán Poma de Ayala (1980: 43, 169, 172, 232). Finally, though for the Andean people clothing was one of the many ways to identify themselves and announce their region of origin and customs, resettling was a standard policy under the Inca empire (Cieza de León, 2005: 347–348). Whole lineages and groups were moved from their origin places to aid the Empire in its colonial endeavour. Hence, we could expect some degree of style blending, just as it happens with the pot's iconography and architectural styles.

In brief, clothing has never been something to determine easily nor taken lightly. The use of documentary sources in conjunction with archaeological evidence allowed us to hypothesize various garments, such as hats, flat ribbons, different types of blankets, and various shapes, cuts, and fabric compositions at use at Guitián. Given the variability and the uncertainty regarding wearables, we decided to generate only two sets of clothing and adornments. Just enough to indicate the difference between the imperial officiants and the local guests. As there are no proper settlement-specific references to build the clothing textures, we designed them entirely from scratch with Adobe Photoshop.

Modelling clothing is not easy. Each character has a different position, so each garment must adjust to the specific pose and bodily structure that we gave them. Some of the characters are taller and more robust than others, which entails generating independent models, one for every wearable. To do so, we used the Marvelous Designer 10 software, which allowed us to create textile templates for each garment and simulate their adjustment to different poses and bodily structures (Fig. 6). We had to model other wearables, such as bracelets, pectorals, headdresses, and other body adornments separately. The design of the ritual headdress of the character standing on top of the *ushnu* was inspired by the finely detailed headdresses worn by the miniatures that accompanied the Llullaillaco mummies (Reinhard & Ceruti, 2000). These have been modelled using the *Hair and Fur* design complement from Autodesk 3D Studio Max. This tool allowed us to imitate the structure of feathers by building hairs and assigning different thicknesses and lengths to each section, as well as complex ramifications across each vector.

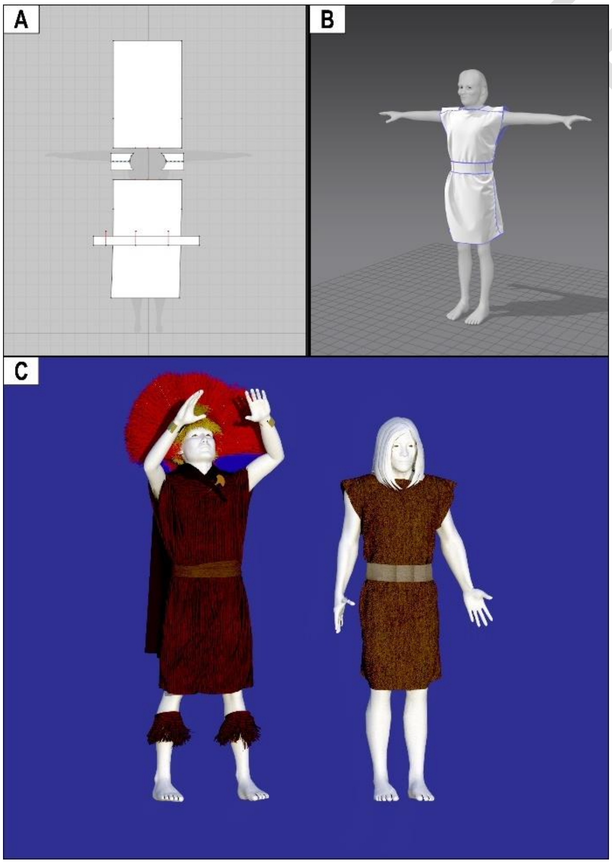


Figure 6: (A) Example of initial bidimensional clothing design, (B) 3D adjustments, and (C) final textured renders (ART render, 22.7dB, 190 iterations, 82 minutes).

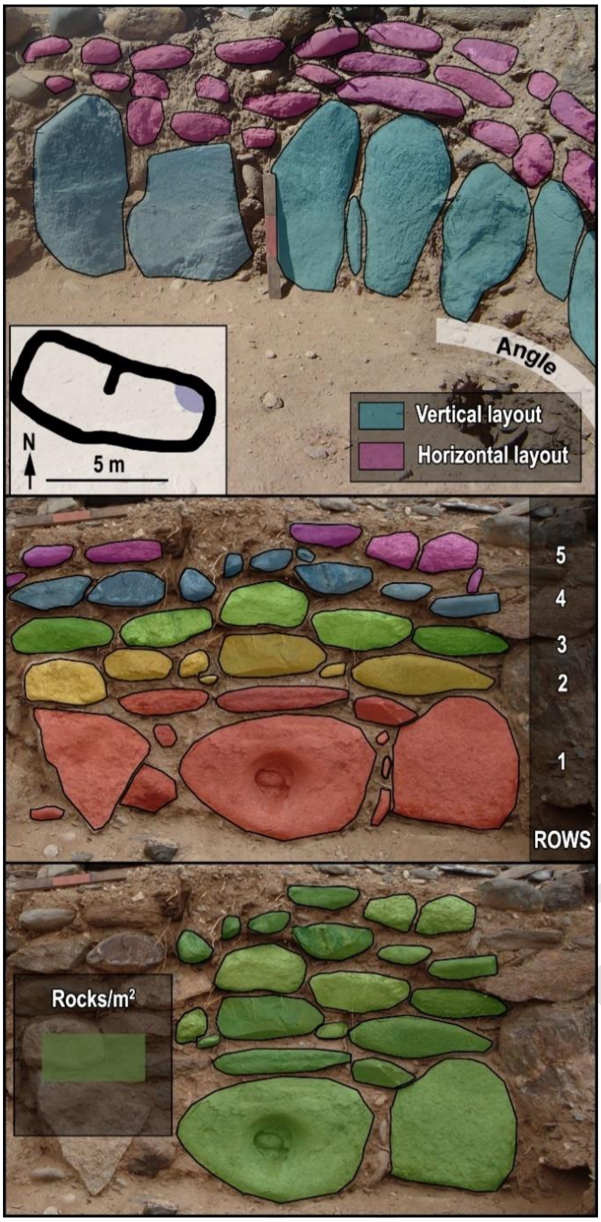
3.3. Architectural data

One of our main fieldwork activities is to characterize local and Inca construction techniques (e.g., Acuto et al., 2008; Ferrari, 2012, 2016; Izaguirre, 2020). Such discrimination is not always easy. We recently began to identify new techniques and blends that emerged from the interaction between local and imperial representatives (see, for example, Ferrari 2019; Ferrari, Leibowicz, Izaguirre, & Acuto, 2021 in press). As has long been recognized by many researchers, the Incas imprinted their presence in local landscapes by sculpting natural features and building with construction techniques that differed sharply from local architectures and landforms (e.g., D'Altroy, 2005; Gasparini & Margolies, 1977; Niles 1999). As in many areas of the empire, distinctive signatures of the Inca architecture in the north Calchaquí valley are: obtrusive building in or around prominent or significant features of the landscape, spatial planning that enhances the place of public squares and *ushnu* platforms, and a carefully manufactured masonry that often includes a careful selection, disposition and stone works (mainly beveling and cutting) to enhance the façades and imprint the landscape with colours and shapes that were not usual before the Inca (Acuto & Gifford, 2007; Acuto 2010; Acuto et al., 2012; Hyslop, 1990; Jacob & Leibowicz, 2011; Jacob, Leibowicz, Acuto, & Moyano, 2013; Ferrari et al., 2017b; Ferrari 2019; Ferrari, Acuto, Leibowicz, Izaguirre, & Jacob, 2021; Williams & D'Altroy 1998; Williams 2004; Williams & Villegas 2017).

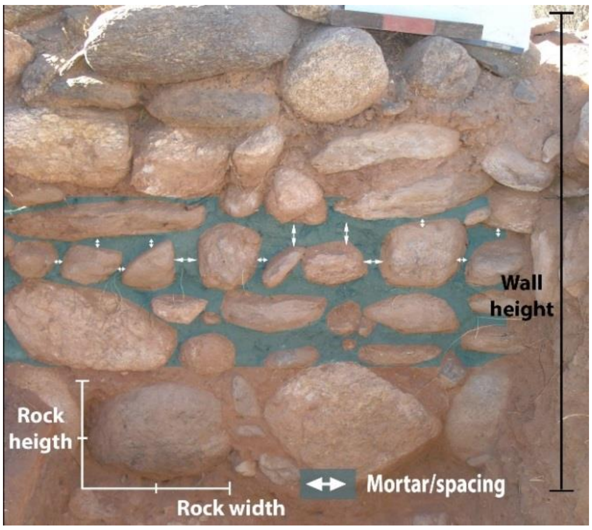
The PAC (archaeological Calchaquí project) elaborated the original plan of this settlement in the early 1990s with a Leitz DT4 laser theodolite and a Red-mini electronic distance meter (D'Altroy & Williams, 1998). Later, architectural surveys and excavations allowed us to identify corners hidden under collapsed walls, establish inner and outer contact angles, and adjust the direction of some walls and the width of some of the accesses. We recorded these minor adjustments with a Stonex R2-A total station. Systematic excavations at Guitián have focused on one of the native residential compounds, the Inca residential compounds, a big typical Inca building usually known as *kallanka*, and, of course, the *plaza* and the ceremonial platform.

We have always tried to survey the composition of the constructions' walls with the greater possible detail (Fig. 7). Our survey sheets include some general characteristics, such as the curvature and contact angles, the current height and width, the façades' materials, the type of mortar, and details such as the rocks' size and number per square meter, their disposition, and mean distances between them We usually complement these architectural surveys with detailed photographs that provide supplementary data to build textures for different walls, mortar types, and sediments.

In the next sections, we will focus almost exclusively on the architectural data of the three pivotal components of Guitián: the *plaza*, the *kallanka*, and the *ushnu* platform.



(a)



(b)

Figure 7: Typical architectural variables established after the excavations. Examples from local (a) and Inca (b) buildings (scale on top right equals 0.3 m).

These buildings are essential to understand where officiants and assistants could have been, how they could have moved, and how the architecture promoted and inhibited specific sights for people visiting the settlement and its central public space.

3.3.1. The Plaza

Inca *plazas* were the preferred places for the most ostensive public celebrations. *Plaza's* sizes vary greatly throughout Inca settlements across the empire, following different contexts and specific strategies in the provinces. However, they all share several features. The Inca architects designed these public spaces to carefully control the sights and movements of those who were about to enter, creating specific scenes and promoting very controlled experiences. In short, to choreograph the participants and effectively convey the imperial cosmology. The imperial architects also devoted significant efforts to control sacred non-human entities' participation, such as the mummies of the noble lineages' ancestors and the non-human entities embodied in salient surrounding landscape features. All of these non-human entities were usually summoned, consulted, lavished, fed, and entertained and had a prominent role during celebratory events.

We can estimate the surface of the *plaza* at 935 m^2. Wall lengths range from 33 m to 39 m, except for the south wall, which is only 18.7 m long, giving the *plaza* a distinctive trapezoidal form. Its walls currently rise a maximum of 1.3 m above the current surface (average of 0.83 m), and have a maximum thickness of 0.8 m and six horizontal rows of river rocks without any modification and settled with mortar at a rate of 26 rocks/m^2 with an average spacing of 8 cm. The angles of union between the walls are straight, and the constructive continuity between them suggests that the builders built it in a single construction phase. Given that the north, east and west sides of the *plaza* are also the façades of the surrounding Inca buildings, we can reasonably hypothesize that the whole Inca area at Guitián has been built according to a single carefully planned event.

The site entrances, pathways, and public and private accesses shapes, dispositions, and locations tell us a lot about Guitián's ceremonial life. To start with, a glance at Guitián's map makes it clear that the social and ceremonial life within its perimeter walls orbited around the plaza. As we mentioned before, the walls that delimit the square to the east, north, and west are the Inca enclosures' façades. Thus, the Incas had privileged access to this ceremonial space.

In addition to these six "private" accesses, the square has three "public" accesses that connect the *plaza* with clear cut pathways that run between local and Inca buildings and extend until three entrances in the perimetral wall (Fig. 8).

The pathway that connected the northwestern perimeter entrance with the public northwestern *plaza* access made people go through a funnel between the high walls of the massif *kallanka* and the Inca residential compounds. During this walk, people had almost no view of the *plaza*. The pathway that led to the southern *plaza* access did not make people walk between walls, but the position and width of the access offered a perfectly framed view of the *ushnu*. The remaining northeast public access connected the *plaza* with the path that

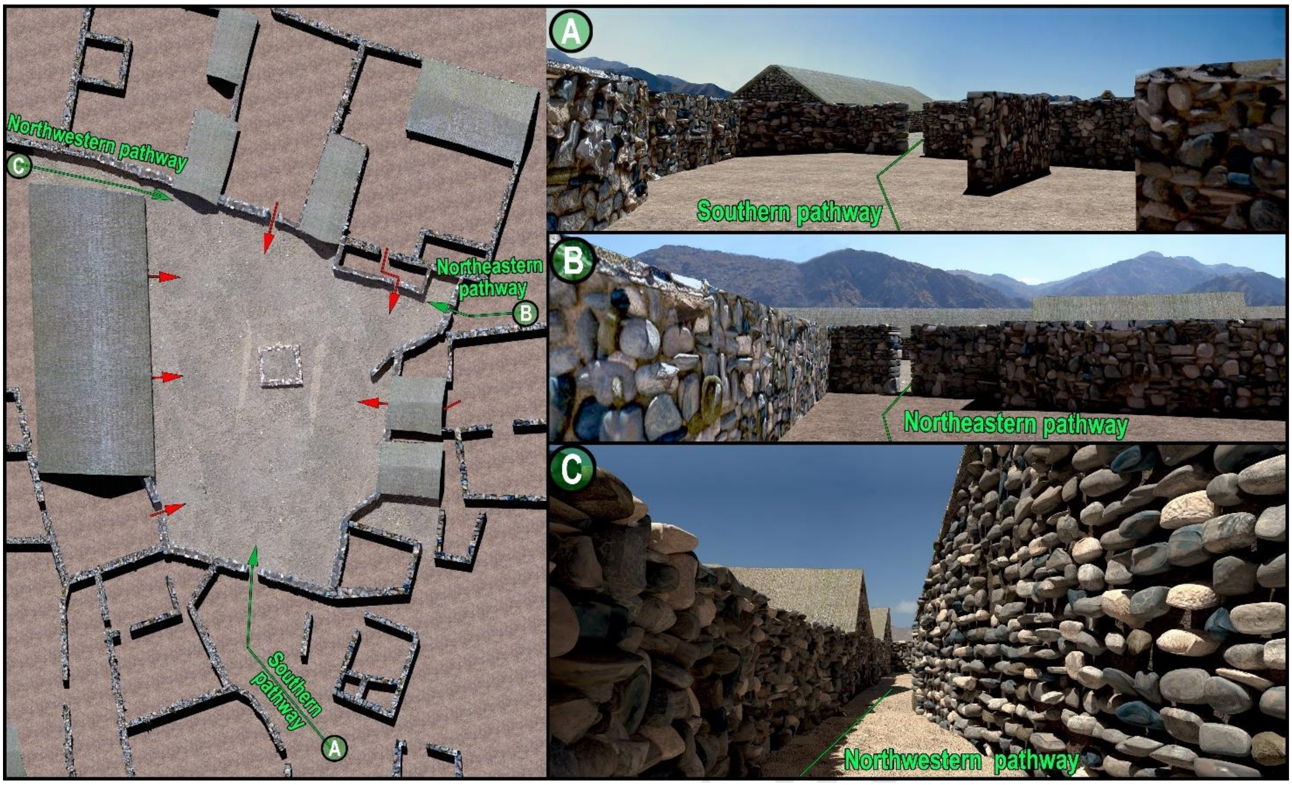


Figure 8: Guitián's plaza and its public and private accesses (left), sights towards the southern (A, 30 dB, 180 iterations, 30 min), northeastern (B, 30 dB, 250 iterations, 60 min) and northwestern accesses (C, 30 dB, 500 iterations, 197 min).

crossed the local area and led to the northeast entrance in the perimetral wall. This access is narrow and certainly discouraged the local settlers from looking into the *plaza* daily (unless they came very close to the access), let alone entering. It also prohibited them from seeing the *ushnu* platform from outside the *plaza*. Such a diverse setting suggests that entering was possible only under extremely choreographed and regulated conditions, and that seeing the *ushnu* platform from outside the *plaza* was not possible unless under very specific events and only for the attendants approaching the *plaza* from its southern side.

Some sight restrictions continued once inside the *plaza*. The position and distribution of the private accesses prevented people in the square from spying on imperial daily life. Except for the *kallanka* accesses, which we will further comment on below, the private accesses that linked the *plaza* with the Inca compounds are also narrow. Most of them barely exceeded 0.6 m in width or were arranged in discontinuous pairs or trios. This narrowness and asymmetry made it impossible for people within the *plaza* to peek inside Inca compounds and get a clear view of imperial life's intimacy. At most, a small surface and only if people were immediately in front of them (unlikely circumstance).

The excavations carried out against the south wall of the *plaza* allowed us to estimate a minimum internal height of 2.32 m for the south wall. Of course, these are minimum heights and could have been slightly higher, although we do not have enough data to estimate its final elevation. Also, this value does not include the gabled façades of the roofed enclosures surrounding the *plaza*, in which case, as we will detail later, at least 3 m should be added to this estimate in some segments. These heights indicate that the walls surrounding the square also inhibited guests from projecting their view outside the *plaza*.

Briefly put, Guitián's design indicates that its purpose was to host public ceremonies attended by select groups of the local population, and the Inca architects ensured that all attention had to be on the centre-staged *ushnu* platform and the imposing *kallanka*.

3.3.2. The Kallanka

Kallanka is the name that receives the large rectangular gabled "sheds" or halls usually located next to Inca *plazas*. Their sizes, constructive techniques, and the number of accesses may vary (e.g. Barraza Lescano, 2010: 171; Muñoz, 2007: 257). However, these buildings regularly have multiple niches, no internal subdivisions, and two or more accesses that connect with the *plaza* (Gasparini & Margolies, 1977: 204; Hyslop, 1990: 18) and sometimes face the *ushnu* platforms (Raffino, 1983: 195) or other landscape features (Cruz, Crubézy, & Gérard, 2013: 103). The activities carried out in the *kallankas* varied depending on the location. Scholars and chroniclers pointed out that these were reserved for the nobility (Salomon 1986: 147) or anyone intimately related to the imperial affairs, as well as lodging during ceremonies and festivities (Hyslop, 1990: 18).

Guitián's *kallanka* measures 27 m and 25 m x 10 m (internal lengths and width, respectively), it currently preserves an average height of 0.8 m on its east side, and the north, east and west walls of this building have an average width of 0.86 m. The south wall has deteriorated, and we could not take accurate width measurements. Though we have not identified traces of stone cutting and selection of raw materials or colouring,

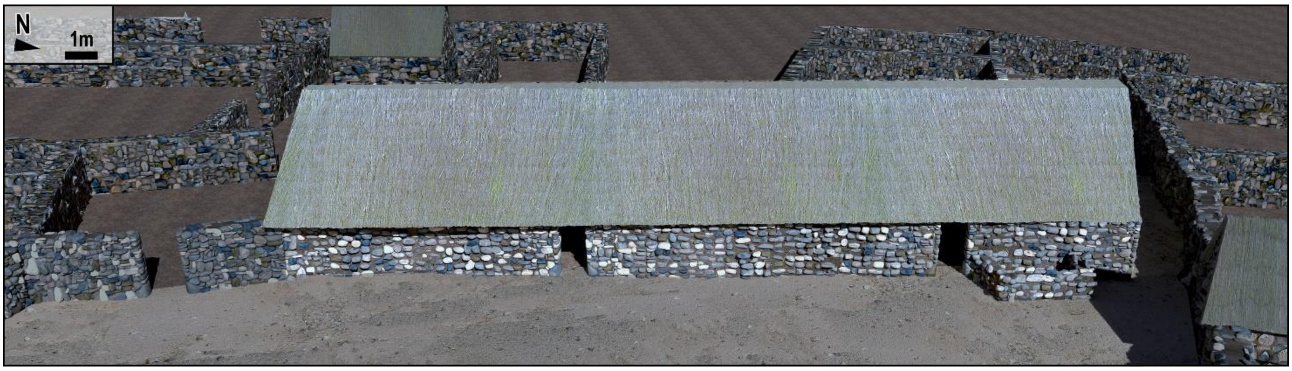


Figure 9: Guitián's *kallanka* (highlighted).

masonry shows some degree of care that is unusual among local buildings. The *kallanka* has double canvas walls, with mostly homogeneous rocks in size (0.26 x 0.17 m) and settled with coarse-grained mortar at an average of 20 rocks/m^2 and an average spacing of 0.035 m in the horizontal axis and 0.08 m in the vertical axis. As we mentioned above, the so-called *kallanka*s had tall, gabled roofs. In Guitián, the gables have sadly fallen, but larger than a usual number of collapsed rocks towards the northern and the southern walls indicate that they were present in this building. To establish their potential heights, we applied the approximately 1:1.3 wall-gable ratio that characterizes the nearby *kallanka* of Potrero de Payogasta (SSalCac 42), just 40 km to the north of Guitián. Its *kallanka* is one of the most impressive prehispanic buildings still standing in Argentina (Schávelzon & Magadán, 1992). In Guitián, the minimum height of 2.32 m and the aforementioned 1:1.3 ratio put the gables of the *kallanka* at 3.02 m, which projects a minimum final height of 5.34 m for this building.

To build the 3D model of the *kallanka*, we created special trapezoidal modules with gradually smaller rocks towards the top of the gables. To build the remaining walls, we first created ten different modules of 20 rocks each, with specific unrepeated rock arrangements, textures, and the aforementioned spacing. Then, we stacked them on top of each other, overlapped some of them, and corrected noticeable junctures (Fig. 9).

Establishing the type of roofing is much more complicated. The excavations in this building did not yield any remain that could offer us some insights about roofing materials and construction techniques. Extensive excavations sometimes unveil traces of the features used to secure the posts, but these are exceptional situations. The only evidence of roofing that we found in Guitián comes from a local residential compound, where the excavations yielded a small section of a few square centimetres of mud with thatch imprints. Due to extensive documentation and archaeological evidence across the Tawantinsuyu, we know that the most usual technique was thatching. Roofs usually consisted of a wooden frame built with various types of beams and cordage on top of which the builders put layers of thatch and mud to achieve durable, somewhat waterproof covering.

3.3.3. The *ushnu* platform

Ushnu is the name with which Andean scholars refer to ceremonial platforms built often (but not exclusively) in the Inca *plazas*, especially in the empire's provinces. Spanish chroniclers have described these platforms as thrones, seats, or stages from which imperial officiants led and coordinated public ceremonies. *Ushnu* platforms were also considered fonts and places through which the sun and the sacred mountains could eat and drink as well as devices that served to make contact with the non-human entities of the cosmos (Meddens et al., 2008, Staller, 2008, Zuidema, 1980). On top of the platform and through special devices, the officiant could contact celestial, subterranean, and landscape sacred entities and ancestors. By paying homage to them, by making offerings, by drinking and sharing with them, the Incas positioned themselves as a critical element in articulating the Andean cosmos' different domains. In doing so, the Inca or his representatives articulated the interaction between different planes, forces, and non-human entities so the animated vital essences could flow, bringing order and balance to the world (Monteverde Sotil, 2010; Pino Matos, 2005; Staller, 2014; Vivanco & Meddens, 2010).

In short, platforms were always the protagonists of the ceremonies, offering a central stage where everyone had to look and pay attention (Fig. 10). Some local people were allowed to interact with the *ushnu*, but only specialized imperial representatives could be on top of it and show off their privileged connection with the sacred.

Guitián's platform is the only structure within the *plaza*. It was built near the centre of it (slightly displaced to the north half) and on top of an embankment that helped to elevate it even more. The excavations that we carried out inside the platform and against the southern canvas allowed us to establish that it had a minimum external height of 1.23 m. This height, added to the embankments' height, brings the platform's top to 1.6 m above the *plaza*. Contrary to the visitors in the *plaza*, the officiant(s) standing on the top of the platform was able to view over the tall walls of the square and between the gabled roofs of the Inca constructions and make contact with the rising sun and paramount landscape entities and places in the area, such as the Nevado de Cachi mountain range, and the agriculture fields (Fig. 11).

3.3.4. Final architectural and 3D modelling remarks

Before diving into how native residents and visitors experienced Guitián, we would like to comment on some additional features of Guitián's architecture and some general decisions we had to make regarding modelling and texturing.

Unlike other Inca buildings in nearby sites such as Cortaderas, Potrero de Payogasta, and La Paya (only 345 m from Guitián), there is no stone cutting among the

Figure 10: The *ushnu* platform near the centre of the *plaza*

(a)

(b)

Figure 11: a) View from the ushnu platform towards the Nevado de Cachi mountain range (28.2 dB, 236 iterations, 116 min) and b) towards the agriculture fields (24 dB, 161 iterations, 93 min).

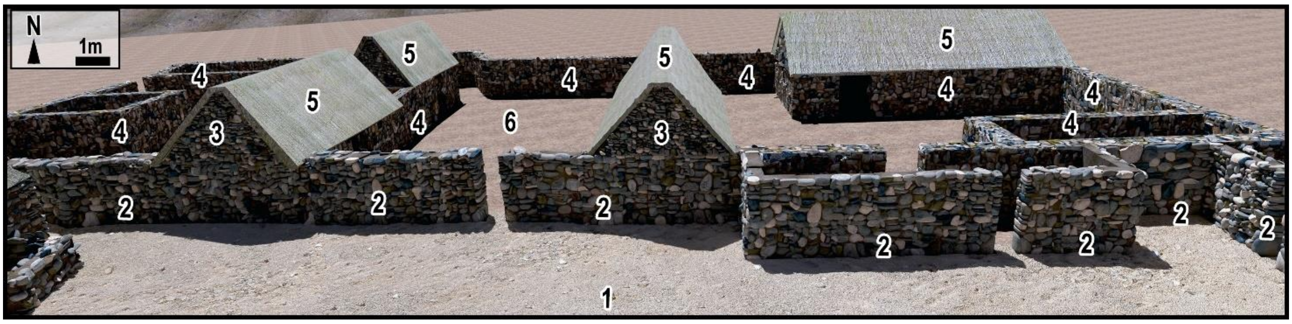


Figure 12: Modelling and texturing strategies. Bumped and displaced *plaza*'s floor (1), wall modules (2), gable modules (3), bumped and displaced walls (4), bumped and displaced roofs (5), floor without a bump and displace modifiers (6).

rocks that make up the walls of Guitián. Indeed, we only detected a small degree of selection and a caring disposition most noticeable in the *ushnu* platform, which exterior canvas had a noticeable predominance of white shades among its rocks. Second, although trapezoidal accesses are a widespread Inca architectural signature, nothing suggests that this may have happened in Guitián. Neither seems to be Casa Morada's case, a remarkable Inca building in the neighbouring site called La Paya and one of the finest examples of Inca masonry in Argentina (see Ambrosetti, 1907; 44, 46; Alfaro de Lanzone, 1985).

Regarding wall modelling and texturing, we had to apply different strategies to balance and adapt an accurate representation with the rendering capabilities of the hardware we used. Detailed models can be very time-consuming and hardware demanding, which is especially noticeable when it comes to model manipulation and rendering with such a large number of rocks. In order to approach this task efficiently, we combined three strategies: rock by rock modelling, module assembling and joining, and simple flat box texturing with bump and displace modifiers (Fig. 12). To model the mortar to settle the rocks, we created a mesh with 0.01 m subdivisions, and we applied normal and displacement maps with a dry mud texture.

Rock by rock wall modelling is self-explanatory and was only possible in the case of the *ushnu* platform and some accesses. Though it favours accurate representation, it is not only time-consuming but also hardware demanding. Module assembling entails building detailed (rock by rock) small wall segments, stacking, and joining them. This strategy saved us from creating and positioning thousands of rocks individually. However, there are obvious risks associated, the most noticeable being identifiable texture patterns and limits between modules. Therefore, we used eleven different rock textures, we randomly modified some individual rocks' positions and textures, and we built special modules for specific walls' sections. This strategy is less time-consuming but not necessarily less hardware demanding. It still maintains rocks as separate meshes and still entails applying bump and displacement maps on each rock to yield rough surfaces. Simple flat box texturing entails placing a simple bitmap (i.e., a photograph) over a flat 3D solid. It "lightens" the model, is far less demanding, and instrumental when rendering images involving distant views. Combining these strategies proved to be efficient enough to obtain the renders that we are presenting here.

Next, we discuss how the locals may have experienced this settlement by living nearby and by entering it, walking towards the *plaza*, and taking part in the ceremonies.

4. Experiencing Guitián: ordinary life and extraordinary events under the imperial shadow

So far, we have talked about Guitián as if to fulfil its true purpose visitors would have had to enter the site, walk the main pathways, and enter the *plaza*. However, Guitián's status was already clear from the outside, especially for nearby settlers inhabiting the sub-surface buildings of Manuel Díaz (about 45 m away) and La Paya (345 m away). It is fair to infer that Guitián must have offered a striking and imposing view to these settlers daily by showcasing gabled roofs that loomed over a massif, well-built perimeter wall. The *kallanka* stood and must have helped make the Inca presence impressive even for local bypassers from other towns and villages of the valley. It is also fair to say that the three sites were part of a single large and quite a unique multi-settlement complex, in which Guitián occupied the role of sponsoring the public ceremonies. No comparable public spaces have been identified in any of the other sites. Indeed, only one local settlement in the north Calchaquí valley (Las Pailas, about 20 km away) had public spaces larger than Guitián's *plaza* (see, for example, Izaguirre 2020).

Undoubtedly, the "Inca experience" must have been much more striking for those who got to visit Guitián's *plaza* and for the natives who dwelled in the eastern enclosures (Fig. 13). Day by day, whether going to the agricultural fields or just by moving between local compounds, the natives that lived in Guitián had a first-hand view of the imperial architecture and how the sun reflected against the tall walls and hid behind the even taller roofs. However, that was pretty much it. The Inca architects did not allow the natives to peek into the imperial daily life, hidden behind high walls and narrow accesses.

By the accounts of chroniclers that witnessed public ceremonies, we know that the sounds of many people's prayers, songs, and multiple instruments made the festivities remarkably loud and noisy (Acosta, 2008: 227 [1590]; Arriaga, 1621: 8; Betanzos, 1992:I: 126- 127 [1561]; Cieza de León, 2005: 121, 181 [1553]; Guamán Poma de Ayala, 1980:I: 228-234 [1615]; Molina, 2011: 39 [ca. 1575]). As we have demonstrated elsewhere, the loss of sound pressure towards local enclosures was notorious, with a perceived loudness four times lower than inside the square (Ferrari et al., 2017a). Succinctly put, Guitián was designed to show off imperial

(a)

(b)

Figure 13: (a) Guitián 3D model as seen from Manuel Díaz (b) Guitián's Inca compounds as seen from Guitián's northeastern local enclosure (24.6 dB, 65 iterations, 123 minutes).

capabilities and constructive proficiency and convey exceptional, memorable experiences to its visitors. Still, Guitián's architects carefully planned the site to make the Inca presence visible but private enough so that people could only speculate about the imperial intimacy.

The most straightforward promotion of the Inca cosmology occurred when selected groups of natives took part in the *plaza* activities. Entering the *plaza* was the best way to engage the imperial liturgy. The paths towards the *plaza* and the sights that people had before entering it also have been carefully thought of when designing this settlement.

4.1. Approaching the *plaza*

Any of the selected group of locals who were to participate from the ceremonies held in the *plaza* had to face first any of the three entrances to the site and walk through the pathways towards the *plaza*'s public accesses. Entering the site through the northeastern perimetral access enhanced the contrast between the local and the Inca architecture and way of living. A mostly straight pathway made people walk between local sub-surface enclosures facing the tall walls of the *plaza*. By starring the horizon, the Incas sought to explicitly differentiate themselves from the local ways of building and living, supporting a powerful narrative by which the Incas imposed themselves on and over the local landscape with a commanding architecture.

Approaching the *plaza* through this pathway revealed nothing of its interior. Even when facing the narrow northeastern access, people could only see a small surface of the square and under no circumstance the *ushnu* platform (Fig. 14a).

After entering the site through the southern perimetral entrance, visitors walked a direct path to the *plaza* near local and Inca buildings. Some of these buildings are poorly preserved, so little can be said about the views immediately revealed after transcending the southern perimetral wall entrance. However, we know that the *plaza*'s south wall's opening framed the *ushnu* platform. Unlike the northeastern pathway, the architects did not seek to provide the entrants with a view that contrasted the local and Inca architecture, nor sought to hide the platform. Quite the opposite (Fig. 14b). The goal was to offer a preview of the main stage and perhaps the officiants already on top. This captivating sight highlighted the imperial protagonism even before entering the *plaza*. It may also indicate a privileged status for the southern entrants, one that gave them preferential access to the platform and perhaps a prominent place in the ceremony.

Entering the *plaza* through the northwest public access provided a markedly different experience. There was no view of the local complexes and no such thing as a full preview of the *ushnu* platform. Instead, it compelled the visitors to walk between the high walls of the Inca

(a)

(b)

(c)

Figure 14: Views before transcending the *plaza* accesses during the equinoxes' sunrise: a) northeastern access (27.2 dB, 307 iterations, 166 min); b) southern access (30.5 dB, 478 iterations, 423 min); and c) northwestern access (29 dB, 160 iterations, 102 min).

residential complexes and the *Kallanka* (Figs. 8c and 14c). To walk through a dark and tall corridor of these dimensions and the contrast with the open *plaza* must have provided a new and impressive experience for the local inhabitants, accustomed as they were to elevated pathways that surrounded their houses and patios. In short, three different accesses provided different remarkable experiences for those who used them, indicating the deeply choreographic nature of the *plaza*'s layout.

4.2. Entering the *plaza*

Once inside, the *plaza* offered an entirely new scene to the attendees (Fig. 15), one that communicated a clear and fundamental difference between them and the officiants on top of the platform. This setting's power did not reside solely in the fact that the platform raised the officiants above the visitors and concentrated all their attention. This elevation allowed the officiants on top of the *ushnu* to project their sight beyond the *plaza*.

Inside the *plaza*, the high walls that defined the perimeter and the distribution and width of the private Inca accesses did not allow the visitors to see much of the surrounding landscape and into the Inca enclosures. On the other hand, as we have seen before (Fig. 11), the officiant(s) had almost non-restricted access to the surrounding landscape. They could greet the rising sun and see the agricultural fields and the north Calchaquí valley's main watercourse to the east. To the south, they could see La Paya, arguably one of the most important settlements in the region and one that undoubtedly housed a nobility member in Casa Morada. Towards the northwest, the officiants could contact the Nevado de Cachi mountain range and praise its powerful summits (Fig. 16). Why was the Nevado de Cachi mountain range so vital in this ritual setting, and how does what happened in Guitián's plaza reflect the occupations and activities in the eastern slopes of said striking landscape feature?

The Nevado de Cachi is a mountain range with nine peaks with heights that range from 5300 to 6380 m above sea level (ASL). Even though Cerro Libertador is the tallest peak of this mountain complex, peak Meléndez stands out due to its position and height (6020 m ASL). With the permanent snows in its summit and pre-summits, Meléndez constitutes the most notable topographic feature of this region. Andean indigenous peoples have considered (and still do) that some aspects of Nature are sacred (or *wak'a*). Those that stood out from the surrounding landscape due to their height, shape, or distinctive colours drew peoples' attention and were highly praised. Mountains of prominent height and permanent snowed summits that people could see from great distances were considered very sacred (*wak'as*). Andean people have considered (and still do) them powerful, tutelary entities that played an essential role in providing water and controlling the weather, promoting the fertility and well-being of humans and their animals and crops (Allen, 2015; Ávila, 1966 [ca. 1598]; Bray, 2013; Duviols, 1967: 20; Farfán Lobatón, 2002; Gose, 2006; Reinhard, 1985). Elsewhere, we demonstrated that the imperial intervention of the Nevado de Cachi's sacred territory aimed to (see Ferrari 2019: 566-627): 1. Create a novel, entirely imperial pilgrimage circuit that enhanced the protagonism of Meléndez's summit. 2. Promote a narrative according to which local groups appeared closely related to lower-ranked mountain entities and the Incas narrowly linked with the summit. 3. Portray the imperial representatives in a privileged condition to mediate between the local people and the most powerful landscape entities through ceremonial architecture that carefully choreographed people's circulation and sights. 4. Formalize the incorporation of Meléndez summit and the human and non-human entities under its domain to an ever-growing network of *wak'as* managed by the empire. In short, interventions across the eastern slopes of mount Meléndez sought to sculpt a landscape that promoted a new hierarchical human and non-human scheme (Ferrari 2019: 637).

Both the locals and the Incas considered the eastern slopes of Cerro Meléndez sacred territories. Both also considered the ascent potentially dangerous, judging by the various strategies they chose to protect themselves from this *wak'a*'s gaze. However, the Incas went further and built a ceremonial platform in its summit, along with settlements and devices in the eastern slopes destined to praise and contact this powerful *wak'a*. Many of these shrines mimicked the summit which follows the common practice in the Andes of creating miniatures of powerful entities to worship them from afar (Brittenham, 2014; Dean, 2006; Meddens, 1994). These miniatures shared the sacred essence with their referent, and only ritual specialists could interact with them.

Platforms throughout the empire have also been regarded as miniaturizations that imitate regional sacred mountains. We sustain that entering the *plaza* of Guitián and being close to the *ushnu* and its white façades was to be close to Meléndez summit. Furthermore, just as in the distant mountain, the Incas and no one else but the Incas were the only ones endowed with the prowess to reach its summit to make offerings and channelling its procreative forces. What the Incas did on the Nevado de Cachi slopes is partially repeated Guitián. Utilizing an imperially designed and controlled circuit, the Incas monopolized the visual connections with Meléndez's summit and other outstanding points of the landscape and presented themselves in a unique capacity to deal with the Andean non-human forces. Guitián was a replica, a less dangerous one, of what happened in Cerro Meléndez, where only the Inca retinue reached the summit. In Guitián's *plaza*, the Incas exposed and showed off this connection, providing a sort of a first-hand but very controlled experience and connection with the mountain that the locals were not allowed (o did not intend) to have.

On the platform, interacting with the sacred non-human entities, the Inca officiant(s) positioned himself as a sacred entity in itself. The locals standing around the *plaza* had nothing to focus on other than the ceremonial platform and the officiants. While the Incas could see and contact the sacred, the locals could see and contact the Inca. Such metaphors were most striking at dawn, especially at the equinoxes, when the platform and the officiant were sun-bathed and simultaneously much of the square remained in shadows, according to what we could determine from our illumination analysis (Figs. 15 & 16). This must have been a captivating setting that must have been hard to forget for those who entered the *plaza*.

5. Concluding remarks: learning (and teaching) with a 3D Guitián

The explanations for the success of a rapidly expansive policy like the Inca are undoubtedly multi-causal. It could not be otherwise, given the enormous area they controlled and the number and variety of ethnic groups and ecosystems they managed to incorporate in such a short time. Scholars have long been studying the means and strategies to finance the imperial expansionary projects and to manage the human resources necessary to sustain extractive policies across local lands. We must seek the fundamentals of Inca expansionism and its success in the annexed territories looking at their

Figure 15: Views after transcending the plaza accesses during the equinoxes' sunrise: a) northeastern access (26 dB, 187 iterations, 135 min); b) southern access (29 dB, 270 iterations, 196 min); and c) northwestern access (23 dB, 122 iterations, 87 min).

capacity to gain and maintain the local adhesion. Hospitality feasts and public ceremonies sponsored by the imperial authorities undoubtedly were among these strategies (Moore, 1996; Morris & Covey, 2003). We must look at how the Inca sites set in motion arrangements and representations with clear, concise, and striking scenes impressive enough so that people could witness, experience, and remember the imperially claimed privileged link with the Andean cosmos. Briefly put, Inca expansion is not only a story of trade and warfare, but also a story of powerful stages and mesmerizing scenes, experiences, and memories.

One of the most important things we seek to highlight is precisely the concrete benefits of performing 3D reconstructions such as the one presented here in the short and long term. Some benefits are strictly related to

Figure 16: *Ushnu* platform and visual connection with the Nevado de Cachi mountain range (30.4 dB, 437 iterations, 226 min).

archaeological research and the tools we use to interpret ancient remains. What did we learn by building this model? Other benefits have heritage implications and open the door for future tasks and goals. What can we do next? Both deserve further synthesis and discussion.

Creating 3D models to discuss the design of Inca settlements is not new and it certainly proved to be quite useful approaches (e.g. Acuto & Gifford, 2007; Astete Victoria, Ziółkowski & Kościuk, 2017; Coben, 2012; Johanson & Frischer, 1998; Mar & Beltrán-Caballero, 2014; Saintenoy, González-García & Fernández, 2019). Regarding the archaeological interpretations of this settlement, in our quest to get closer to the scenery that local visitors might have witnessed when they took part in an Inca ceremony, we complemented classic archaeological fieldwork with new technologies to replicate to the best of our capabilities some of the scenes that people got to witness daily and while attending to some imperial ceremonies. The implications of building a model capable of yielding the view that people might have had transcended the creation of a mere representation or reconstruction (which is in itself a valuable task). It prompted us to pay new attention to things that did not become evident during fieldwork or immediately after it. Traditional architectural, archaeological analysis of Guitián's excavations helped us establish the foundation of the *plaza*'s perimeter walls, their potential height, the depth of the occupation floor, the foundations of the *ushnu* platform, and its orientation and height. Nonetheless, it was the process of creating a 3D model that allowed us to establish that the officiant(s) on top of the platform could look well beyond the *plaza*'s walls and what they were able to see.

It is also what helped us better understand what living next to the Inca retinues might have generated. In this particular case, it is clear that the imposing architecture of the Inca architectural complexes throughout the western area of the site must have stood out due to their sturdiness and impressive height that contrasted markedly with the local way of building. For those living in Guitián's local compounds, these day-to-day scenes were highlighted with the first rays of the sun reflecting along the eastern façades of these tall buildings. In itself, a phenomenon that was unusual in local subsurface constructions. It was also the process of building the 3D model and the proper illumination setting that forced us to examine and hypothesize about lighting as a fundamental part of the ceremonial scenes. Results indicate that as in other sites (see, for example), the imperial architects took note of the sun's position and designed some of their architectural complexes according to its illumination. In this specific case, illumination might have also been vital to highlight the *ushnu* platform protagonism even further.

Detailed architectural data helped us model the walls' textures with great detail. However, it was "building" them as accurately as possible that led us to notice some interesting architectural traits, such as the prevalence of whitish rocks in the outer façade of the *ushnu.* It is subtle but noticeable enough, and it further supports the role of this platform as a miniature of the far snowcapped mountain known as Cerro Meléndez. As we mentioned before, this mountain is precisely the one that stands out most locally and the one that the Incas chose to build a pilgrimage circuit across its slopes and a large platform on its summit. As we mentioned before, pilgrimage circuits and platforms on summits and pre-summits of the most important sacred mountains were frequent. It was a way of assimilating and articulating places central to the local liturgy. As in other empire sites, the Inca architectural compounds in Guitián controlled who, when, and where specific people could establish visual links with these prominent landscape features.

Briefly put, building this model prompted us to interpret that in Guitián, far afar from the slopes and summit of Cerro Meléndez, the imperial architects staged a miniature version of the privileged relationship they created with this mountain. On top of the *ushnu*, on a central stage elevated above the square, well within sight of the guests and receiving the morning's first lights, the officiant replicated, actualized, enacted, and flaunted the Inca link with the non-human. Admittedly, we would have hardly had even a glimpse of this kind of association had we not done the exercise of building a detailed and realistic model of Guitián and its 3D surroundings.

Regarding the patrimonial or "non-strictly-academic" implications of building such models, advantages vary and feedback into each other. Heritage public dissemination in museums and archaeological sites might articulate adequately and attend to the needs of developing countries (ICOMOS-OEA, 1967). 3D digital heritage production, access and continuity has been a frequent theme recognized by the UNESCO "Charter on the preservation of digital heritage" (2003), the London Charter (London Charter, 2009) and in the principles of Seville (International Forum of Virtual Archeology, 2011), which purpose is to preserve the authenticity of the 3D models generated according to the guidelines established by ICOMOS in Nara, Japan, in 1994 (ICOMOS, 1994).

New technologies are becoming a vehicle that facilitates the interaction between research teams, members of local indigenous communities, tourism agencies, and provincial cultural heritage management organs. These interactions are often problematic and usually stressful. Though tourism can become a substantial income source for local indigenous communities, it has to be carefully planned to warrant the preservation of the cultural heritage (Endere, 2016; Guráieb and Frére, 2008). However, in many parts of the world, local indigenous communities are gradually gaining voice when it comes to make, defend and consolidate their identities, which frequently collides with what government agencies or museums seek to project. Both have traditionally tended to avoid indigenous claims, thus generating tensions regarding what these organs choose to expose and to silence (Crespo, 2017). Especially in the last 20 years, it has long been claimed that incorporating the local indigenous communities as active and equally critical social actors should be a fundamental aspect of heritage policies and academic practices (Curtoni, 2004). Creating updateable, easily accessible, wide-audience appealing, user-friendly, and disputable representations such as 3D models of archaeological settlements is one step further in that direction. At the very least, it creates instances to view, understand, share, and discuss perspectives about the past and the future of patrimonial goods and strategies, which helps design long-term plans that include local indigenous communities and strengthen their impact on national heritage policies.

It also creates other types of bridges between the academy and a non-academic audience by establishing new arenas for discussing and adjusting tensions between archaeological knowledge and local indigenous interests. Visiting archaeological sites with detailed models loaded on a standard tablet makes it easier to work side by side with local indigenous community members at the sites, share visions of the past and create a more collaborative and fruitful work scheme. Of course, there are some obvious advantages in visiting and examining archaeological sites with local communities and sharing perspectives regarding constructive techniques, the height and width of walls, the choice of materials, or the shape and position of specific constructions, which local communities generally know best. Local expertise usually proves to be quite informational, especially for archaeologists who limit their contact with these sites and landscapes to field seasons once or twice a year. Both scientific knowledge and cultural heritage benefit if developed in conjunction with local communities, giving the indigenous communities active participation without omitting their contributions, questions, and interests (Cook Inlet Tribal Council, 2017).

A challenging task arises. How do we contribute to reach and include a wider audience? Times are changing. Children and teenagers, immersed in today's digital reality, are pretty fond of social networks and video games. Especially in the last years, interesting archaeological endeavours demonstrated the advantages of developing multimedia strategies to reach a wider audience. Some examples are the development of interactive video games (Mol, Arlese, Boom & Politopoulos, 2017), interactive museum experiences through augmented reality (Mc Kinley & Damala, 2013) and guided video tours (e.g. Lascaux 19000 years ago), and augmented reality based visits offered to archaeologists and non-archaeology related visitors (Bjørkli, Ledas, Liestøl, Stenarson & Uleberg, 2018). Nowadays, it is much easier to reach young audiences through applications and models like the one presented here, broadening the age range for people who can approach and become interested in local heritage.

Joining new technologies with heritage dissemination is a no-return path (Endere, 2016). Digital dissemination has the advantage of converting existing information from the real world into a visually appealing model, thus improving the assimilation of knowledge, facilitating cognition and the synthesis of large amounts of data, and allowing the apprehension of information through engaging and amusing interactions. It facilitates communicating and protecting heritage, especially with sites that suffer constant deterioration. It also makes academic extension activities simply more engaging and entertaining. This way, it might be easier to face these challenges and commit ourselves to articulate our passion for the past with our current engagement and future responsibilities.

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