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Under the eye of the Apu. Paths and mountains in the Inka settlement of the Hualfín and Quimivil valleys, NW Argentina

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ABSTRACT

The analysis of the nature and strategies of the Inka expansion in the peripheral areas of the empire, NW Argentina among them, has long been a subject of interest for researchers. In recent years, new perspectives have started to focus on an alternative view of the Inka expansion in this area. Among these, the processes of symbolic appropriation, manipulation or re-negotiation of the regional landscapes by the Inkas have been highlighted by some authors, by paying attention to the symbiotic relationship between settlement, architecture and natural features in the landscape. Within that framework, this paper will analyse the distribution of archaeological sites from the Inka period in the Hualfín and Quimivil valleys, located in the province of Catamarca (Argentina). The results of our analysis suggest that the layout of the Inka settlements and roads in that region was influenced by two main factors: distribution along natural corridors and maximization of the visual presence of the Cerros de Aconquija, a prominent mountain range where an Inka ceremonial site was built. Considering the relevant role of certain landscape features in the Inka worldview, this is interpreted as part of a symbolic appropriation of the surrounding landscape.

1. Introduction

One of the most controversial issues in Inka research is the nature of their political expansion and the strategies they used in order to absorb local populations. According to most contemporary researchers, these strategies were different depending on geographical, chronological and ethnic factors. It is generally agreed that the dynamics of Inka occupation were diverse across the empire, depending both on the social and cultural characteristics of the different local groups and the varied interests and motivations of the empire (Alconini, 2007). Peripheral areas of the *Tawantinsuyu* (the "Land of four quarters", the Inka name for their Empire) are particularly interesting cases since the most characteristic material features of the empire are often absent there or are present in not so archetypical forms. A number of authors have explored this variety of mechanisms used by the Inka in the outer areas of the *Tawantinsuyu* (Lorandi, 1980; Dillehay and Netherly, 1988; Bray, 1991; Pärssinen and Siiriäinen, 1998; Raffino and Stehberg, 1999).

This also applies in the specific case of NW Argentina, where different motivations and mechanisms of Inka rule have been highlighted, such as a strong military presence to guarantee the appropriation of economic resources, mainly metal ores (Raffino, 2008), a complete transformation of the local populations in order to conform to a completely new political scheme (Acuto, 1999) or a remarkable variety of mechanisms to adapt to the disparate characteristics of the local groups (Williams, 2000; Lynch et al., 2013; Giovannetti, 2016).

In recent years a range of new perspectives on Andean archaeology and anthropology have started to focus on an alternative view of the process of the Inka expansion in this area. Without denying the importance of the political and economic interests of the Inkas, these new approaches have begun to explore other dimensions of the Inka expansion in NW Argentina. For instance, the role of ritual violence (Acuto, 1999; Nielsen and Walkers, 1999) and the importance of the transmission or imposition of symbols in the legitimation of positions of power, e.g. through iconography and morphology in ceramics (González Carvajal, 1998; Bray, 2003, 2004; Páez and Giovannetti, 2008; Giovannetti and Páez, 2009), are dimensions which have been explored in depth, thus allowing for a more comprehensive view of that historical process (Williams, 1999, 2002–2005; D'Altroy, 2003; González and Tarragó, 2004, 2005; Tarragó and González, 2005).

Félix Acuto has been one of the main proponents of this renewed vision (Acuto, 2005, 2007, 2012; Acuto et al., 2012; Acuto, 2016). He has shown particular interest in the processes of symbolic appropriation of the landscape by the Inkas. For instance, along these lines, he has recently interpreted the effort made by the Inkas, in the North

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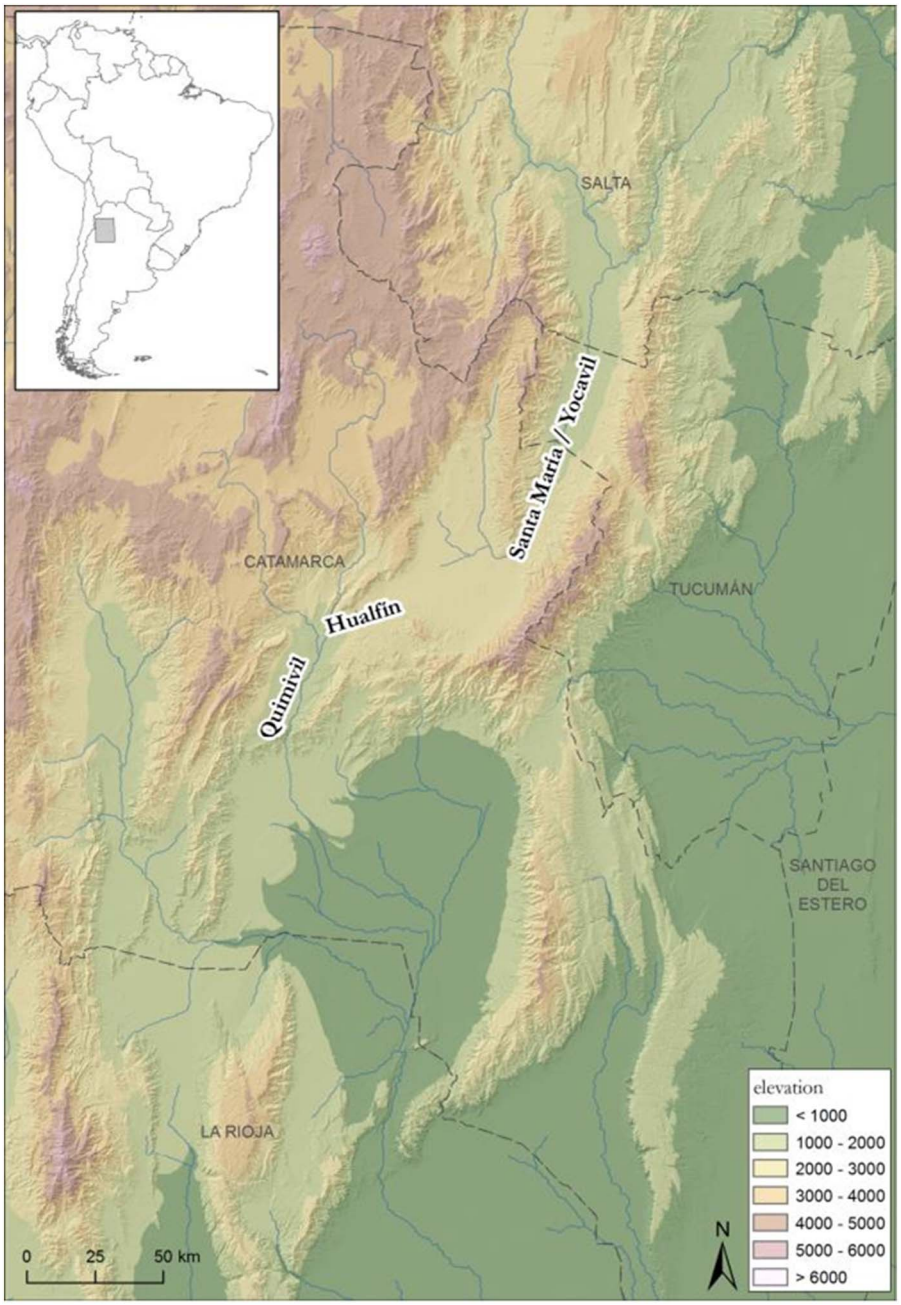

Fig. 1. Location and context of the study area, showing the modern provincial limits.

Calchaquí valley, to build sacred compounds including sanctuaries, roads, pilgrimage sites and rock art on the higher mountains (*cerros*) (Acuto et al., 2012, Acuto, 2016). This, and other similar proposals, emphasizes the need to go beyond the mere consideration of the economic and political aspects of the Inka expansion (without necessarily denying them) to also focus on other dimensions through a vision that exceeds the analysis of individual sites, in order to understand the broader changes which occurred in wider landscapes.

2. Objectives

In this paper we shall attempt to make a contribution towards the understanding of the way in which (if any) the expansion of the *Tawantinsuyu* into an area of NW Argentina implied some form of appropriation, manipulation or re-negotiation of the regional landscapes. Our case study shall be the valleys of Hualfín and Quimivil, in the province of Catamarca (Fig. 1).

As mentioned above, the recent literature on this matter has explored the idea that the expansion of the *Tawantinsuyu* into the peripheral provinces entailed the shaping of certain forms of Inka state landscapes. From this very general idea, our specific hypothesis is that, beyond the use of mechanisms which could be described as economic, political or coercive, those Inka landscapes would have had a strong "ideological" component, by which we mean the deployment of a network of sacred references which were used as part of the legitimising devices of Inka hegemony over the local groups (Acuto, 2005). This, following Acuto and as we will further elaborate in the next pages, means that what we call here "ideological component" must be considered as deeply interconnected with the economic and political strategies in the configuration of Inka landscapes.

During the Inka period, nature and society in the Andes were parts of a single, unique reality within a worldview that matches what Descolá describes as an "analogical ontology" (Descolá, 2012): for the Inka, natural elements such as rivers, rocks or mountains, among

others, were not considered things or objects, but *Wak'as*, non-human agents in the complex universe of those populations (Bray, 2015). Among the *Wak'as*, for the Inka, *Apus* (snow-capped mountains) were especially important places in their world view: "Some mountains were (and still are) considered as ancestors, places of ancestor origin, transformed ancestors, gods that controlled water and weather and agricultural activities, givers of protection, fertility, keepers of the social order, and places to communicate with supernatural levels" (Acuto, 2005: 228). Beyond the use of military force and other forms of physical, direct authority, the Inka state would also have put a lot of effort into guaranteeing the support of these non-human agents ("forces of nature"). At the same time, the Inkas would have been interested in showing off their capacity to position themselves as mediators between these non-human agents and the local populations. For instance, this has recently been proposed by Pino Matos (2016) in the case of the Central Andes, where the Inka appropriated the sacred local landscapes in order to assimilate them into the *Tawantinsuyu* system. These practices served to gain control over local sacred spaces in order to establish a twofold relationship of dominion over and integration with the conquered populations. Archaeologically, this would become visible in the reconfiguration of ritual landscapes via the construction of architectural elements such as *ushnu* platforms (artificial platforms for ceremonial and administrative functions located at the center of the main squares in the most important Inka settlements), high-altitude sanctuaries or through the well-known *Qhapaq ucha* ritual (the sacrifice of children), which created an ideological link between the local sphere and the State (Pino Matos, 2016). Similar practices are beginning to be documented in our study area on the scale of individual settlements, such as in El Shincal and Hualfín Inka (Lynch et al., 2013; Lynch and Giovannetti, 2018).

Within this framework, in this paper we shall seek indications relating to the symbolic appropriation of certain attributes of the landscape from the locational characteristics of archaeological sites from the Inka period. More specifically, we shall analyse the logic behind the spatial location of both the newly founded Inka settlements in the area and, especially, the layout of Inka roads, and examine to what extent they can be related with the symbolic appropriation of the surrounding landscape. Incidentally, our approach will involve the use of certain digital tools for the archaeological analysis of the landscape that have not previously been applied in this area.

3. The study area: the Hualfín and Quimivil valleys

The Hualfín and Quimivil valleys are located in the central-western province of Catamarca, in the NW region of Sierras Pampeanas (Caminos, 1979). Surrounded by higher mountain ranges, these valleys are located at an altitude of ca. 2000 m (Fig. 1). A number of sites are known here from the pre-Inka period (900/1000 CE–1430 CE), locally known as Belén after their pottery style and pattern of settlement, such as Puerta de Corral Quemado, Corral Quemado and Eje de Hualfín, among others (Balesta et al., 2011). Recent work in these Pre-Hispanic sites has allowed to propose a view of the relationship between the local populations and the Inka as mediated by a local elite, with periods of higher and lower tension, which would have generated persistent conflicts with the rest of the population, as well as with other Belén groups. It is suggested that these conflicts may have caused the abandonment and burning of some local settlements, and triggered regional movements (Balesta et al., 2011).

3.1. Inka sites in the Hualfín and Quimivil valleys

Exploring the spatial distribution of the main Inka sites in the area is a good way to approach, in the terms described in the previous sections, the mechanisms used by the empire to gain control over this vast territory. Fig. 2 shows the location of the main Inka sites in the area. By "main sites" we refer to sites with architectural elements related to administrative and symbolic roles (plazas, kallankas, ushnus, and storage facilities); sites which would have played a central role in the imperial rule of the area (Hyslop, 1990, Williams, 2000, Raffino, 2008, Giovannetti, 2009, Lynch, 2011, Lynch et al., 2013, among others).

Here, the Inka occupation was basically organized around two main sites: Hualfín Inka, in the Hualfín valley, and El Shincal in Quimivil (Fig. 2), both of which shall be described in the following paragraphs. Around them, other subsidiary sites developed with diverse characteristics; for example the metallurgical site of Quillay (Raffino et al., 1996; Spina and Giovannetti, 2014) and the sites located in the Azampay valley, whose production would be controlled from Hualfín Inka and El Shincal (Balesta et al., 2011); see Williams (2000) for a detailed description of all the sites shown in Fig. 2.

This site of Hualfín Inka is located next to the Hualfín River, in a place where previous occupation has not been documented. It would have acted as an administrative, economic and ceremonial centre from the 14th century onwards (Raffino et al., 1982; Lynch, 2011; Lynch et al., 2013). Some characteristic Inka constructions are found here: a main, large square or *haukaypata* with an *ushnu* (ceremonial platform) and a *kallanka* (large roofed building). Around the square, settlement compounds, storage facilities (*qollqas*) and *patios* have been documented. Abundant pottery has been found in these areas corresponding both to late local and Inka styles (1000–1430 and 1430–1532 CE respectively).

Field projects carried out on the site in recent years have interpreted its construction in terms of a powerful mechanism for cultural and symbolic dominion through a combination of architecture and spatial location in what was considered to be a key confluence of communication and exchange routes (Lynch, 2011). Although local settlements have been found in the valley, the Inka site was founded in a new spot, a few kilometres to the east of the areas where human occupation had developed in the pre-Inka period (Lynch et al., 2013) (Fig. 3).

El Shincal is located 60 km to the SW of Hualfín, in the Quimivil valley. It has been studied archaeologically for decades by different teams (González, 1966, Raffino, 2004, Giovannetti, 2009, among others). It is considered to be the most important administrative, political and ceremonial Inka site in the region, quite probably a provincial capital (*wamani*) for this area of the *Kollasuyu* (the southern part of the empire). A complex and rich Inka architecture has been documented here, including, again, *kallankas*, *ushnu* and *haukaipata*. The site embraces two terraced hills with carefully built stepped access paths which, along with some other relevant constructions in the site, have been related to ceremonial practices connected to astronomical events (Giovannetti, 2016) (Fig. 4).

Both archaeological sites show architectonic differences that prevent to recognize them as hierarchically equivalent (Lynch et al., 2013). Both were built in specific places where no previous occupation is known, which can be interpreted in terms of setting a sharp divide with respect to local traditions. This is similar to what happened in other regions in Northwestern Argentina, where the local landscapes were also transformed with the construction of new, often monumental, Inka sites (Acuto, 1999; Williams, 2002–2005).

Besides settlements, an important ceremonial site (La Ciudacita) is known in this sector (Hyslop and Schobinger, 1991). It is located at the top of Nevados de Aconquija, the highest mountain range in the area, for which a relevant symbolic role in the Inka period has been suggested (Scattolín and Korstanje, 1994; Ataliva et al., 2010; Moyano and Díaz, 2015).

3.2. The Inka roads in the Hualfín and Quimivil valleys

As is well known, the main element used by the Inkas to integrate and connect their vast empire was the road system (Raffino, 1981; Hyslop, 1984, 1990), which acted as a truly active political agent (Saintenoy, 2013; Moralejo and Gobbo, 2015). It should be expected, then, that these main sites are distributed following the main Inka

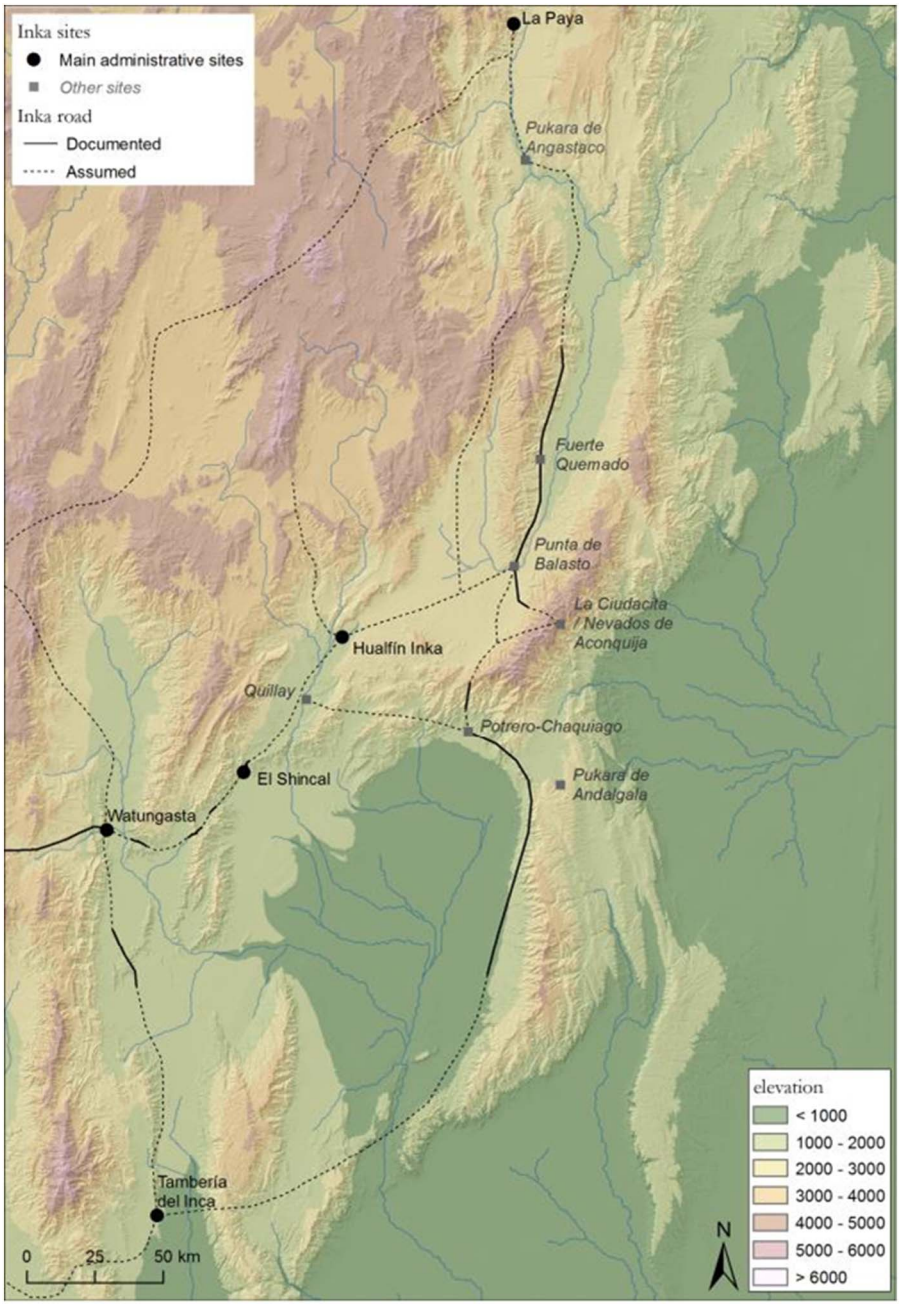

Fig. 2. The Inka road system and main Inka sites in the area; roads adapted from Raffino et al. (2012) and Moralejo and Gobbo (2015).

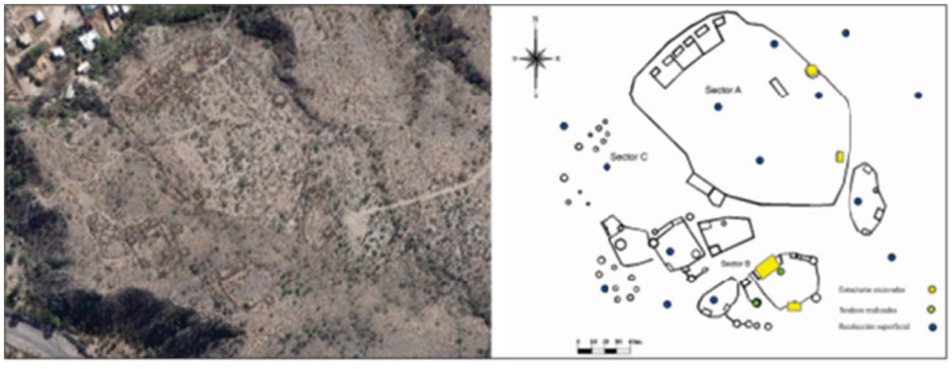

Fig. 3. Satellite view and site plan of Hualfín Inka (image © 2015 DigitalGlobe and site plan by J. Lynch).

Fig. 4. El Shincal: a view of the main plaza and one of the terraced hills (photo by M. Giovannetti).

roads.

For this particular area, the layout of the Inka road system was first studied by Raffino et al. (1999) and recently refined with the mapping of some secondary paths (Raffino et al., 2012) and the identification in the field of some new sections (Moralejo and Gobbo, 2015). Although still fragmentary, since only some parts of the road have been documented in the field, > 300 km have been directly documented, as shown in Fig. 2. What is more relevant for our analysis is the fact that these portions have allowed us to understand which natural corridors were chosen to connect this large area. Although this doesn't have to be necessarily the case in any other area of the Andes, in this particular region valleys are the main areas used historically as "natural corridors". From Tambería del Inca, a first branch joined Watungasta and El Shincal, with a second one following a more easterly route. Both converged in the Hualfín valley, to then follow the Santa María valley, where a large portion of the road has been documented in the field around Punta de Balasto and Fuerte Quemado. From this valley, the road would have continued northwards, towards La Paya, located in the Calchaquí Valleys. This corridor was also part of the route taken by Diego de Almagro on his journey from Cuzco to Chile in 1536, a journey which would have followed the main Inka road across the Santa María, Hualfín and Quimivil valleys towards Watungasta and further west (Vitry, 2007).

4. Materials and methods

As shall be described below, our analysis was carried out by approaching the area of interest (the Hualfín and Quimivil valleys) from a regional perspective in order to explore the significance of these particular valleys, and the Inka sites they contain, within the wider regional landscape. As our objective was to analyse the logic behind the spatial location of the main newly located Inka settlements in the area, and to what extent they can be related with the symbolic appropriation of the surrounding landscape, we decided to explore the two basic mechanisms through which space can be appropriated by means of human-embodied interaction: movement and vision (Criado Boado, 1993, de Certeau, 2000, Ingold and Vergunst, 2008).

It is not by chance that these two topics have been the subject of significant attention from those interested in landscape-based archaeology and, quite significantly, the focus of many digital approaches, for instance Llobera (1996, 2000), Gillings (2009), Llobera et al. (2011a, 2011b), Paliou (2013), Polla and Verhagen (2014), among many others. Indeed, digital tools have proved their usefulness in this field not only to shorten the time of data processing and analysis, but also (and especially) to design new frameworks of reference for approaching the archaeological space in different, novel ways, "not necessarily with the intention of mimicking "reality" and/or other complex notions frequently found in interpretive narratives" (Llobera, 2012: 506).

Our analysis will rely to a great extent on the computational modelling of the possibilities for human movement and vision in the study area. This will be done with the aim of exploring "the range of possibilities associated with certain processes or actions" (Llobera, 2012: 505), in our case the location and layout of the Inka settlements and paths in the area. It is important to note that we are not taking here the a priori assumption that the spatial layout of those Inka places can be understood simply by invoking certain simplistic factors, in terms of efficiency and optimal decisions, which constitutes a common critique against computer modelling in archaeology (see Llobera, 1996, Llobera, 2012 and Hacıgüzeller, 2012 for a detailed discussion on this issue). Both human movement and vision are conditioned by certain basic physiological facts. However, the processes and actions which occur in relation to them are determined by many other, contextually-determined, factors. While in some contemporary contexts efficiency might be expected to be the main factor influencing human decisions, we do not assume that this also had to be the case in the past. Since such contextually-determined actions are what we wish to be aware of when exploring the past, an analysis of the extent to which they differ from certain "theoretically optimal" decisions may constitute a good basis to approach this issue; the extent to which these physiological restrictions may have influenced the layout of the Inka sites in the area is precisely the heuristic mechanism we shall use in this analysis. Indeed, we are particularly interested in finding pieces of evidence which cannot be understood in such basic and deterministic terms, as it is from here that we will be able to extract some meaningful conclusions regarding the context we are analysing.

The analytical tools employed are rather simple. As far as visibility is concerned, we merely made use of conventional viewshed calculations with the parameters described below. In terms of movement, instead of relying on the well-known Least Cost Paths, our hypotheses benefited from the calculation of Focal Mobility Networks (Llobera et al., 2011a, 2011b), or MADO in its original Spanish acronym (Fábrega-Álvarez, 2006): an approach to the potential movement across a landscape in relation to one single destination. In contrast with LCP, a MADO shows all the most probable routes across a landscape that, if only movement costs are considered, would lead to a particular destination, with no predefined starting points. Movement costs were calculated considering terrain slope as the only impedance, and quantifying them according to the proposal of Llobera and Sluckin (2007).

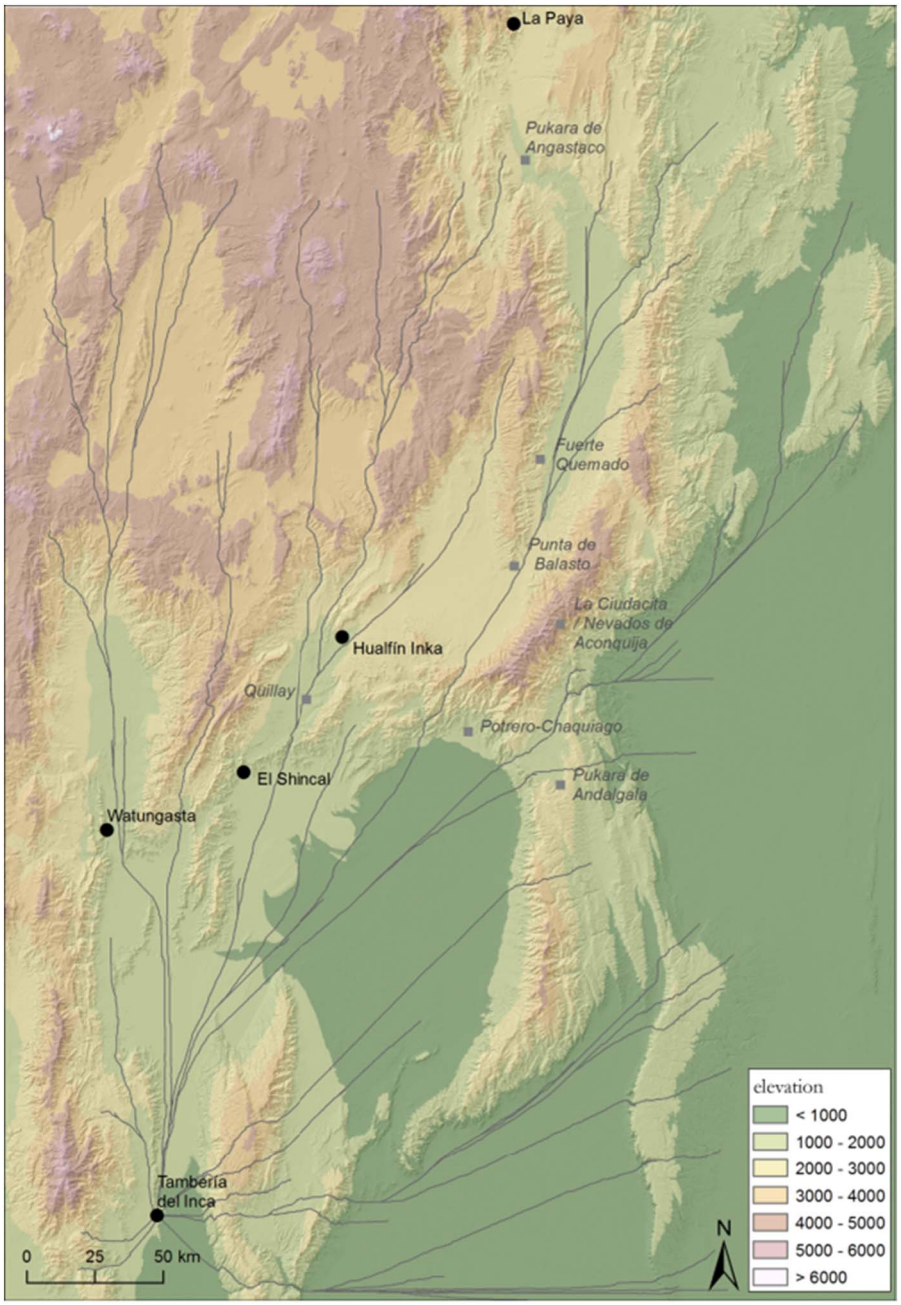

Fig. 5. Results of the MADO analysis towards Tambería del Inca.

Finally, we also made use of some morphological and hydrology analysis tools to extract some topographic elements of interest within the landscape, such as the summits of the highest *cerros*, as described below. This was principally done with the ArcHydro Tools toolbar in ArcGIS 10.4, and with some simple raster reclassifications.

The main dataset used in our analysis was the SRTM Plus DEM, a void-filled version of NASA's Shuttle Radar Topography Mission DEM, which was produced by combining the original radar interferometric data with elevation data from the ASTER GDEM2 to fill in the existing voids. The raster dataset has a spatial resolution of ca. 30 m. At the geographical scale used in our analysis, this gives an accurate representation of the relief, with enough detail to perform some basic analyses where topography plays an essential role. All the analyses described below were performed in ArcGIS 10.4, using a Dell Precision workstation with an Intel Xeon x5650 processor and 12 Gb of RAM.

5. Analysis and results

5.1. The Hualfín and Quimivil valleys within the wider landscape

A quick look at Fig. 2 shows that all (or most) Inka sites in the area are located along the routes of the Inka roads. This is not surprising, since those routes have been reconstructed precisely by joining the main Inka sites known to date with the sections directly documented in the field strongly supporting this proposal. However, the interesting point here would rather be to analyse the logic behind the route of the Inka road itself (as in Guimil-Fariña and Parcero-Oubina, 2015). Was it merely a matter of efficiency (to minimize time and effort) or were other factors considered in its layout? What is the relationship between the roads and natural corridors in the landscape? What are the main nodes determining the route of the main road? Were the sites built along the road or did the road join the sites established beforehand?

To approach these issues, and also to attempt to understand the true

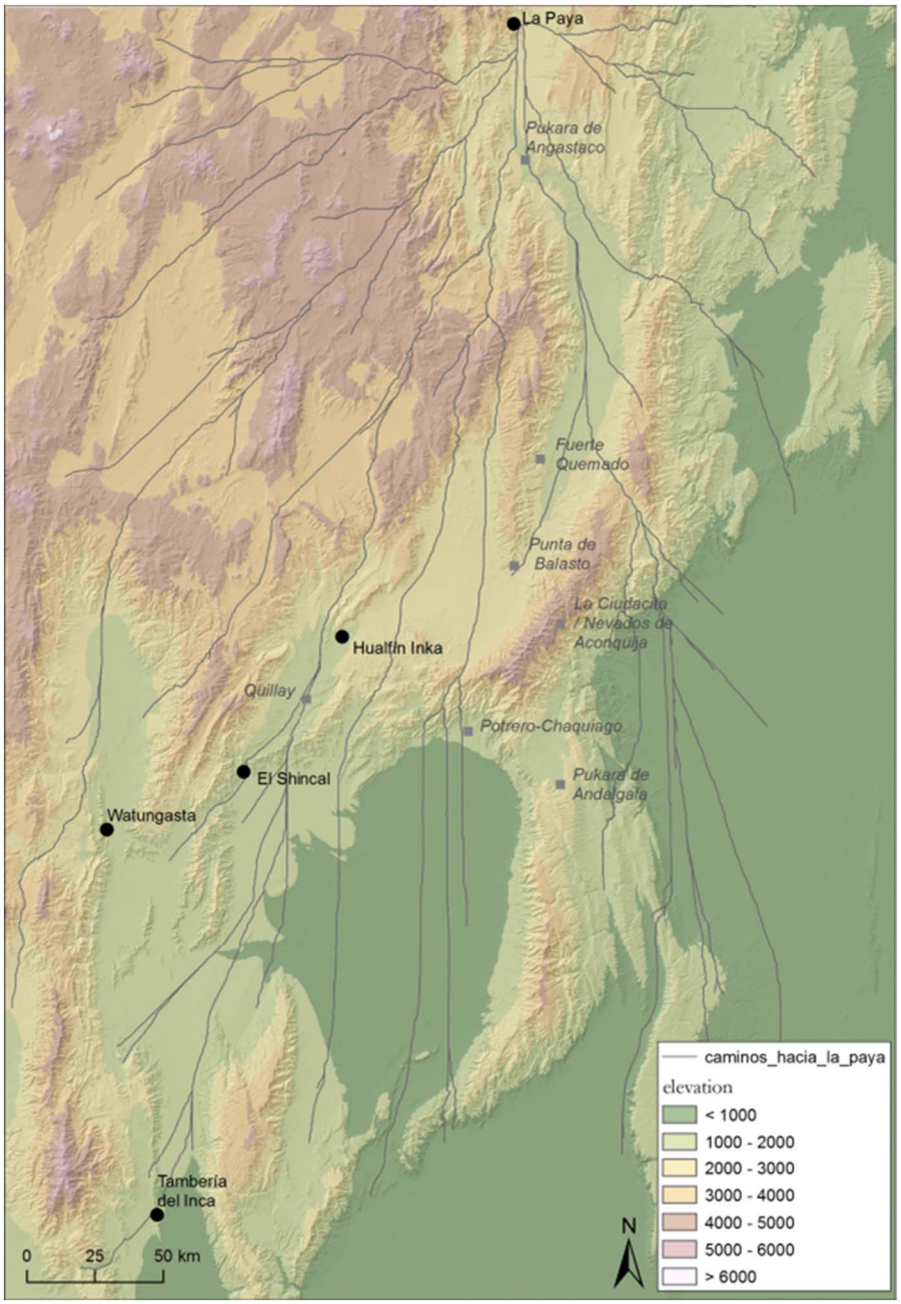

Fig. 6. Results of the MADO analysis towards La Paya.

Table 1
Shortest linear distance from sites in the area towards the MADO routes heading to Tambería del Inca or La Paya.

Site	Distance (km)	MADO towards
Pukara de Angastaco	1.1	La Paya
Fuerte Quemado	5.0	Tambería del Inca
Punta de Balasto	1.6	La Paya
Pukara de Andalgala	5.5	Tambería del Inca
Potrero-Chaquiago	2.2	La Paya
La Ciudacita/Nevados de Aconquija	17.6	Tambería del Inca
Hualfín Inka	2.8	Tambería del Inca
Quillay	0.1	La Paya
El Shincal	0.9	La Paya
Watungasta	4.4	Tambería del Inca

importance of movement as a location factor for these main Inka sites, we relied on the calculation of Focal Mobility Networks (Llobera et al., 2011a, 2011b), as described in Section 4 (hereafter we shall use the Spanish acronym MADO for simplicity). A MADO modelling process is based on the accumulation of the potential for movement across the landscape towards a specific place.

To test the extent to which the Hualfín and Quimivil valleys, and the Inka sites within them, are located along natural corridors, it was necessary to start by approaching them from a distance. That is, we placed them in the centre of a large study area, and selected some destinations (nodes) of interest, located some distance away, at the opposite ends of the study area. The places we selected as nodes were La Paya and Tambería del Inca, two important Inka administrative sites far away enough for our purposes from the Hualfín and Quimivil valleys. The final study area (show in Fig. 2) has an extension of almost 7000 km^2 and includes a notable diversity of landscapes and altitudinal zones, from < 1000 to > 6000 m.

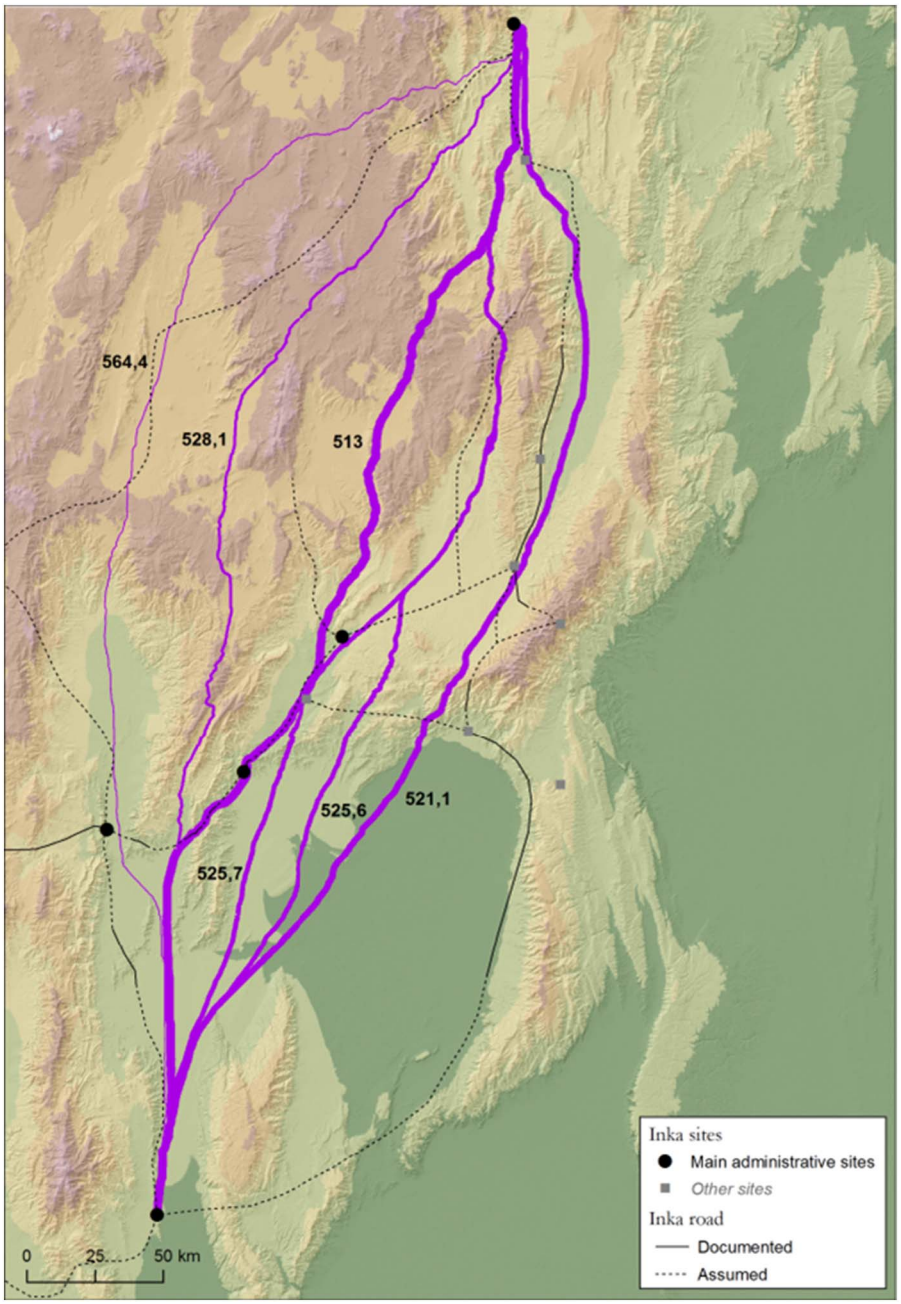

Fig. 7. The most probable routes between Tambería del Inca and La Paya compared with the route of the Inka roads. The thicker the line, the shorter the route (length in km is shown for each route).

Table 2
Distance from each site to the closest theoretical path (as shown in Fig. 7).

	Site	Distance (km.)
Administrative sites	El Shincal	0.9
	Hualfín Inka	2.8
	Watungasta	4.4
Other sites	Quillay	0.8
	Pukara de Angastaco	1.1
	Punta de Balasto	2.4
	Fuerte Quemado	7.7
	Potrero-Chaquiago	12.6
	La Ciudacita/Nevados de Aconquija	22.4
	Pukara de Andalgala	51.8

Table 3
% of the theoretical MADO paths shown in Fig. 7 within different buffer distances from the Inka roads.

Distance to closest Inka road (m)	Lenght of MADO paths (km)	% of MADO paths	Accumulated %
500	137.00	4.31	4.31
1000	125.38	3.95	8.26
2000	267.11	8.40	16.66
5000	690.66	21.73	38.39
10,000	535.98	16.87	55.26
> 10,000	1421.86	44.74	100.00
Total	3178	100	

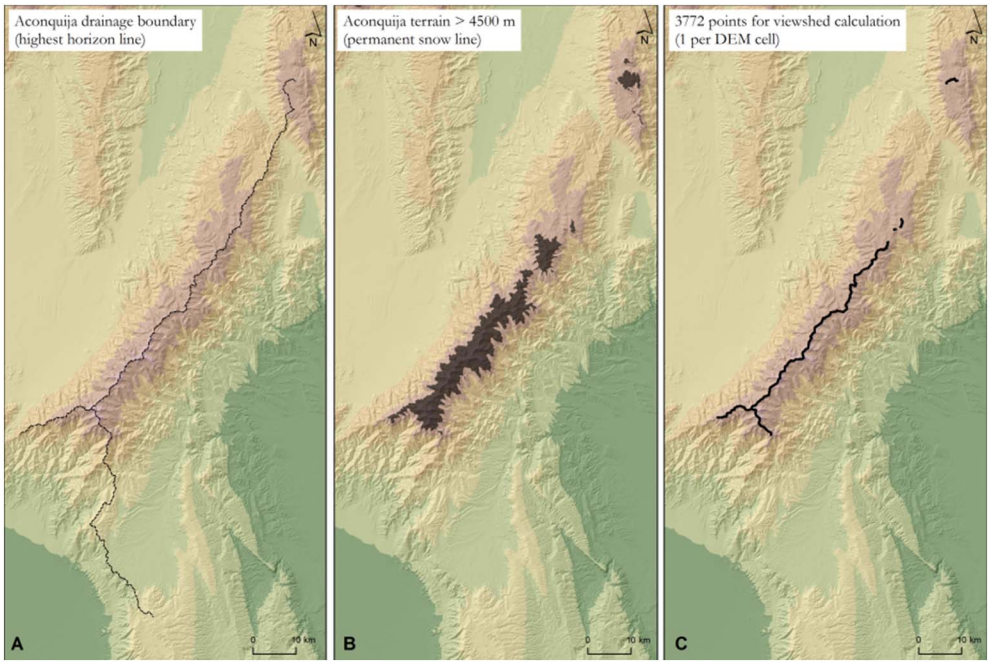

Fig. 8. Steps for the calculation of observer points in the Sierra del Aconquija.

Once the study area and the two destination points at the northern and southern extremes had been selected, we calculated the MADO for both La Paya and Tambería del Inca, with the aim of exploring to what extent the remaining sites are located in "natural corridors" across this area. Fig. 5 and Fig. 6 show the results for Tambería del Inca and La Paya respectively.[1] It can be clearly seen that all the sites (with the exception of La Ciudacita in Nevados de Aconquija) are located in close relationship to these "natural corridors" heading towards La Paya, Tambería del Inca, or even both of them at times, as Table 1 shows.

This first stage of analysis supports the idea that mobility was a main factor in the shaping of the Inka occupation of this area, as well as in the foundation of new sites in that period. However, mobility in such a complex and administrative-oriented context as the Inka Empire is more about fixed and formalized roads than about fluid and easily-changing tracks. Therefore, it is necessary to dig a little deeper in this direction, and search for the logic behind the development of the specific roads that crossed this area and their specific relationship with these "natural corridors".

A combination of the results of the two MADO analyses may give us further clues on the more probable routes used to cross this area. Fig. 7 shows the layout of the coincident lines in the two MADO analyses, which gives us an equivalent to the different optimal pathways linking La Paya and Tambería del Inca. The lines shown in this figure were obtained by simply selecting those overlapping segments of the lines obtained from both sites independently (those depicted in Figs. 5 and 6). A MADO analysis produces a "branched network" of interconnected segments (potential paths) that converge towards the destination point. We selected those specific segments that overlapped and also the remaining route towards the destination points. As opposed to a traditional least cost paths analysis, which merely allows for a calculation of the first optimal route between two points, our approach here shows a network of the potential main corridors to connect these two places if only physical energy expenditure is taken into account. Again, most of the sites are located along one of those lines, thereby reinforcing the point of view that they are actually located along "natural corridors". This is further confirmed if we measure the distance of each site to the closest theoretical path (Table 2), although some large distances still exist in some cases.

The line width in Fig. 7 corresponds to length, which enables us to visually understand what the optimal choices would have been (in terms of time and effort) in order to cross the area. A comparison with the route of the Inka roads (Fig. 2) shows that there is actually a good degree of coincidence between the road and a combination of the two shortest lines shown in Fig. 7. Again, a quantitative approach provides a better view on that; we have measured the similarity between the theoretical paths and the Inka roads by determining the proportion of the former that lie within a buffer distance from the second latter, as suggested by (Goodchild and Hunter, 1997). The results are still too preliminary, since the theoretical paths shown in Fig. 7 are far more dense that the network of Inka roads. But in any case > 50% of these theoretical paths (nearly 2000 km) are located within 10 km from the proposed Inka roads (Table 3).

This supports the idea that, in effect, the Quimivil and Hualfín valleys are relevant places for the arrangement of mobility on a regional scale. This may be a good argument in the understanding of the establishment of the important Inka sites (El Shincal and Hualfín Inka) here from a more or less practical and functional point of view.

However, there is still a significant degree of divergence between the distribution of the sites and the route of the main Inka road on the one hand and the "natural corridors" on the other. To the east of Hualfín the Inka road connects Hualfín and Punta de Balasto, continuing to the north along the Santa María valley up to Fuerte Quemado and Pukará de Angastaco. This implies a "non-optimal", longer way round which deserves further analysis, since two shorter options are easily available.

5.2. *Under the eye of the "Apu"*

What else could have conditioned the settlement and layout of the roads? Are there any attributes of the surrounding landscape which may have had an influence? Some of the proposals summarized in the previous sections offer an interesting arena to explore: in particular, the relevance of the higher mountains (*cerros*), considered as Apu, non-human living beings with a direct and permanent influence on the life cycles of all surrounding beings. While their presence may seem ubiquitous in the Andean area, the fact is that the fragmented topography

[1] The threshold to extract the lines visible in these figures was set at 1,000,000 cells (900 km^2 of "mobility basin" at this resolution, for further details see Llobera et al., 2011a, 2011b.

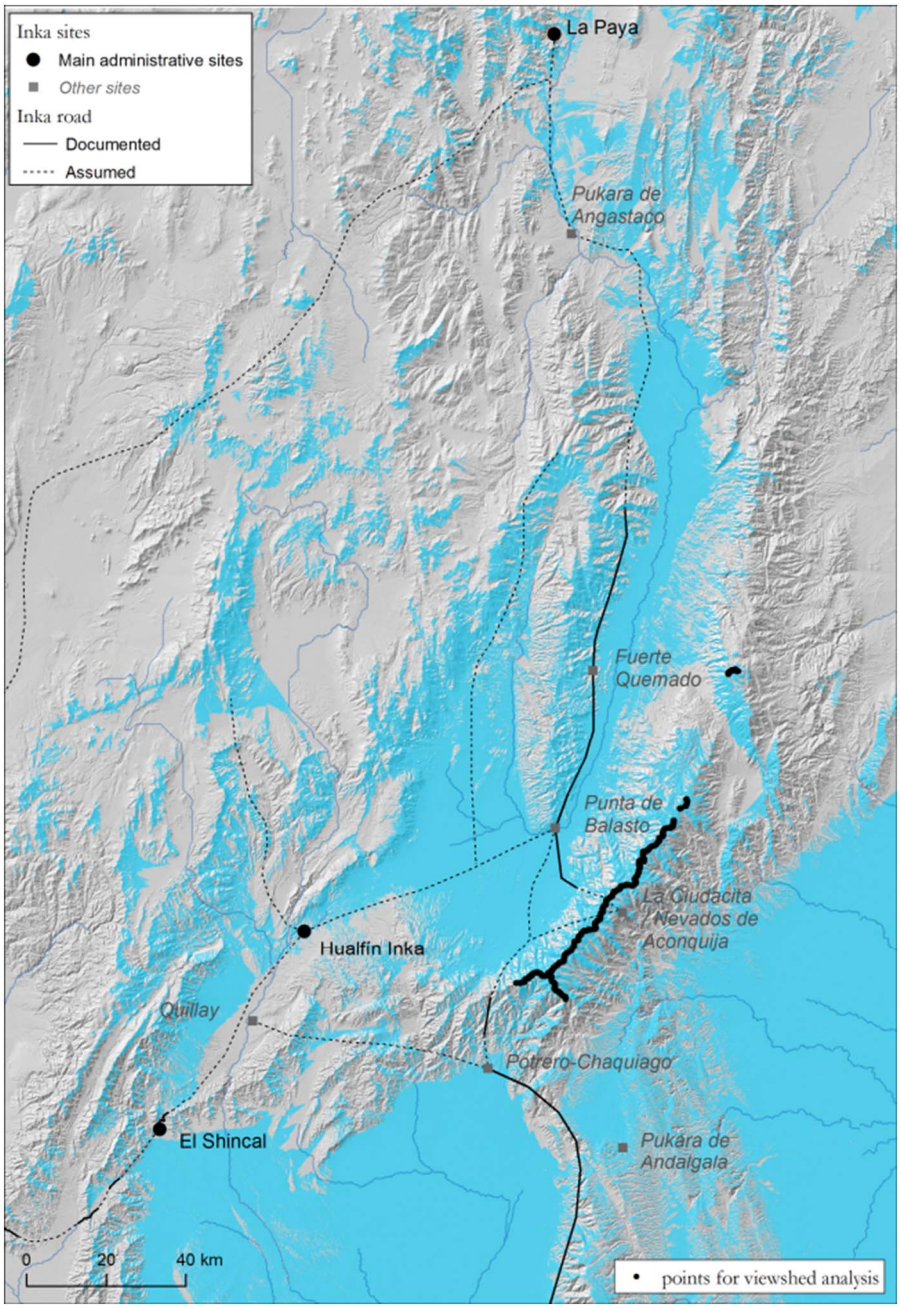

Fig. 9. Results of the viewshed analysis: areas from which the high mountains are visible.

creates frequent changes in whether they are visible or not. Furthermore, their "symbolic control" may have played a relevant role in the Inka expansion (Acuto, 2016). In this area, as we have previously described, the main *cerros* are those of Aconquija, and their symbolic relevance in the Inka period is clearly proved by the construction of the ceremonial site of La Ciudacita (Hyslop and Schobinger, 1991; Moyano and Díaz, 2015).

Other authors have suggested that, among the Inka strategies for re-ordering the landscape, "the imposition of a rigorous discipline on the indigenous vision, controlling what could be seen looking out or looking in" (Acuto et al., 2012: 1141) can be included. This constitutes a stimulating idea worthy of exploration in our case. In order to approach the possible influence of the presence of the cerros in the Inka settlement of this area, the decision was taken to examine whether they are all located in places from which the high peaks of Aconquija are visible.

In order to achieve this, we performed a rather simple viewshed analysis in which, instead of calculating the viewshed for every single point in the area, in order to check whether or not the mountains were visible from them, we considered a reverse approach: calculating the viewshed from the mountains, setting an observer height of 0 m and a height of 1.7 m for each terrain cell as considered for visibility (the OFFSETB option in ArcGIS). Subsequently, the only remaining step was to determine the observer positions, for which we followed a rather simple analytical flow (Fig. 8). Since we were interested in the visibility over the mountain peaks, we first performed a hydrological analysis in order to determine the drainage boundaries. Then, we reclassified the DEM in order to isolate the terrain over 4500 m in height, which is the lower limit of the permanent snow line, an aspect which makes a significant difference in how the mountains are viewed and perceived from the surrounding landscape, especially at a long distance. Finally, by intersecting these two layers and creating a point for every single cell in the 30 m DEM, we obtained a set of 3772 points which constituted our input layer for the viewshed analysis.

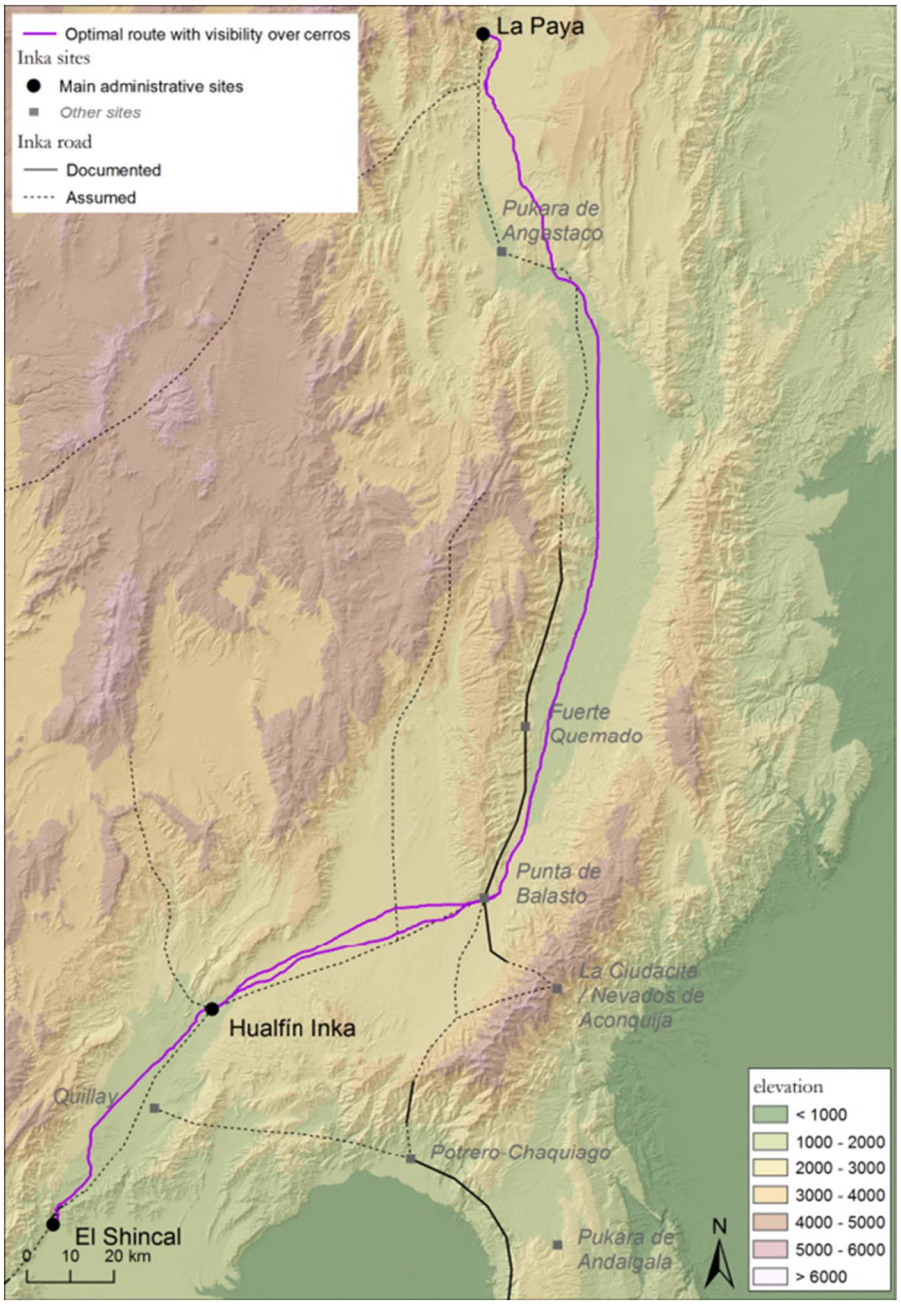

Fig. 10. Least cost routes between El Shincal and La Paya considering the lack of a visual connection with the *cerros* as a cost factor.

Table 4
Distance from each site to the closest theoretical path (as shown in Fig. 10).

	Site	Distance (km)
Administrative sites	El Shincal	0.04
	Hualfín Inka	0.3
Other sites	Quillay	7.2
	Pukara de Angastaco	10.3
	Punta de Balasto	0.2
	Fuerte Quemado	5.2

Table 5
% of the theoretical MADO paths shown in Fig. 10 within different buffer distances from the Inka roads.

Distance to closest Inka road (m)	Length of MADO paths (km)	% of MADO paths	Accumulated %
500	39.10	8.38	8.38
1000	23.45	5.02	13.40
2000	79.38	17.00	30.40
5000	179.91	38.54	68.95
10,000	136.37	29.21	98.16
> 10,000	8.59	1.84	100.00
Total	466.80	100	

The results (Fig. 9) show that most of the Inka sites have a line of sight towards the high *cerros*, although this was already noticeable in the field from the sites themselves. The interesting question here was to use those viewshed results to further refine the mobility analysis, in order to check to what extent maintaining a line of sight towards the *cerros* might also have been a factor in the shaping of the Inka road system.

This seems to be quite obvious at first sight, merely by a visual comparison of Fig. 2 and Fig. 9. However, the point becomes more solidly established when the MADO analysis is repeated, this time adding an extra impedance to the areas from which the *cerros* are not visible (a similar approach to Verhagen and Jeneson, 2012). This time we limited our analysis to the area between El Shincal and La Paya, since this was the portion where a divergence between the optimal routes and the Inka road was documented. The parameters used in the analysis were the same as before, except for the addition of a 2 × increase in the cost impedance for those areas from which the *cerros* are not visible.[2] This does not block these areas completely, but merely gives preference to moving along the visible zones, as long as an excessively long detour is not implied.

The combined results of the MADO towards La Paya and El Shincal (Fig. 10) now show one main single route across the whole area: the only potential path which would have connected these two places with a minimum of effort while maintaining a line of sight towards the cerros, whenever possible. Indeed, it shows a surprisingly good match with both the route of the Inka road and the location of the main Inka sites. Again, a quantification will give us a better understanding (Table 4):

As the table shows, most of the sites are now much closer to the nearest theoretical path; actually, considering the resolution of our analysis, the distances are especially small for the two administrative sites, El Shincal and Hualfín Inka, whose location might be more deeply influenced by these "symbolic aspects", as proposed in the first sections. A similar pattern is visible if we measure the similarity between this theoretical path and the proposed route of the Inka road (Table 5).

Here, almost the entire theoretical path is located within 10 km from the proposed route of the Inka road, and a quite remarkable 69% (> 300 km) is within 5 km. At some points, there is a slight deviation which can easily be attributed to the broad scale of our analysis and the data we used and also to the rather general scale at which the Inka road has been mapped in some sectors. However, besides these factors, the results coincide very well with the main corridors that were used at that time (and continue to be used today) to cross this region, and to shape the distribution of the newly founded Inka sites.

6. Discussion and conclusions

The results of our analysis provide empirical evidence to support some of the proposed ideas regarding the mechanisms of Inka expansion into the outer areas of the *Tawantinsuyu*. For the specific case of NW Argentina, the role of symbolic and ritual strategies, which has been already explored on the scale of the architecture of individual sites such as El Shincal (Giovannetti, 2016), might be extended to a wider, landscape scale (Acuto, 2012; Acuto, 2005). In our case, we have tried to understand to what extent the location of sites and the layout of the Inka paths may be related to factors reaching beyond what could be considered as purely functional or efficient. In particular, we have found that maintaining a permanent line of sight towards the *Nevados de Aconquija*, a probable Apu in the period, aids further understanding of the distribution of the Inka sites and roads in this area, despite the fact that the visual relationship with them does not provide any obvious practical benefit in terms of movement. To our view, the most parsimonious interpretation for the correlations we have identified is that maximizing the visual presence of the *cerros* was something deliberately taken into account by the Inka and it conditioned, at least partially, the location and layout of both settlements and roads, in accordance with what has been observed, on a different scale, in other sites of this area (e. g. Acuto et al., 2012, Giovannetti, 2016).

On the other hand, it is important to highlight the fact that our analysis has some limitations, especially relating to the broad scale at which it was carried out. This might explain, for instance, the divergences shown in Fig. 10 in the area around Pukará de Angastaco and La Paya. However, it is also possible that in those areas, some 150 km from *Nevados de Aconquija*, other "natural" elements play an equivalent role as landscape landmarks to be appropriated. Future work at more detailed scales, and/or focused on other areas, will help to clarify this aspect.

Of course, we are not suggesting that any other mechanisms or interests were absent in the Inka expansion in this area. Rather, we are attempting to contribute towards a more balanced understanding of the question. As archaeological research on the Pre-Hispanic period progresses, the need to consider the complexity and multidimensionality of the Inka expansion across the Andes becomes ever clearer. Our contribution is merely an initial step towards approaching these aspects in the area of Catamarca, although it is hoped that it might open the way to the exploration of similar issues in other regions, and to contribute towards a more balanced view of the expansion mechanisms of the Inka social order.

[2] This weight was selected arbitrarily, and after testing with different values up to 10 ×; no noticeable differences were obtained. The aim was merely to add an extra impedance to the zones without a line of sight towards the *cerros*.

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