

## 5.2 Using Google Earth and GIS to survey in the Peruvian Andes

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### **ABSTRACT**

In the Central Cordillera of the Andes in Peru, the Ayacucho region offers a landscape of mountains and deep, warm valleys, whose vast ecological diversity has encouraged human settlement from the Archaic period, 10,000 years ago, up to the present day. The Choquek'iraw-Chanca project, initiated in 2007, aims at understanding the process of occupation in one part of this region, the 'La Mar' province (so-called *Oreja de Perro*, 'dog's ear'), which is located between 1,000 and 4,500m altitude, in the north-east of Ayacucho (the regional capital).

Two survey campaigns were carried out in this area. These indicated a significant regional occupation that began soon after the Formative Period ( $\pm 500$  BC) and continued through the Inca era (1532 AD), with a stronger presence of sites from the Late Intermediate period (1000 to 1400 AD), probably belonging to the Chanka. Today, there are still a few hamlets of people speaking the Quechua dialect and their rural lifestyle seems to be similar to that of pre-Columbian times.

Preliminary work on high definition satellite images from Google Earth enabled us to identify a few archaeological sites (villages and ceremonial centres). By surveying on foot, we discovered other sites that were not visible on Google Earth (burials in rock shelters, agriculture terraces and ancient roads). Each site has been properly recorded and referenced by GPS points (UTM WGS 84). This helps us integrate all the information recorded on the ground into a computer database and a Geographic Information System (GIS). The distribution of archaeological sites – most of which are Chanka villages – can then be shown on different base maps. The GIS also provides the opportunity to make thematic maps carry out spatial analysis via digital terrain model (DTM), e.g. slopes, site inter-visibility and visibility between sites and their environments, which allowed us to understand the different patterns of landscape occupation.

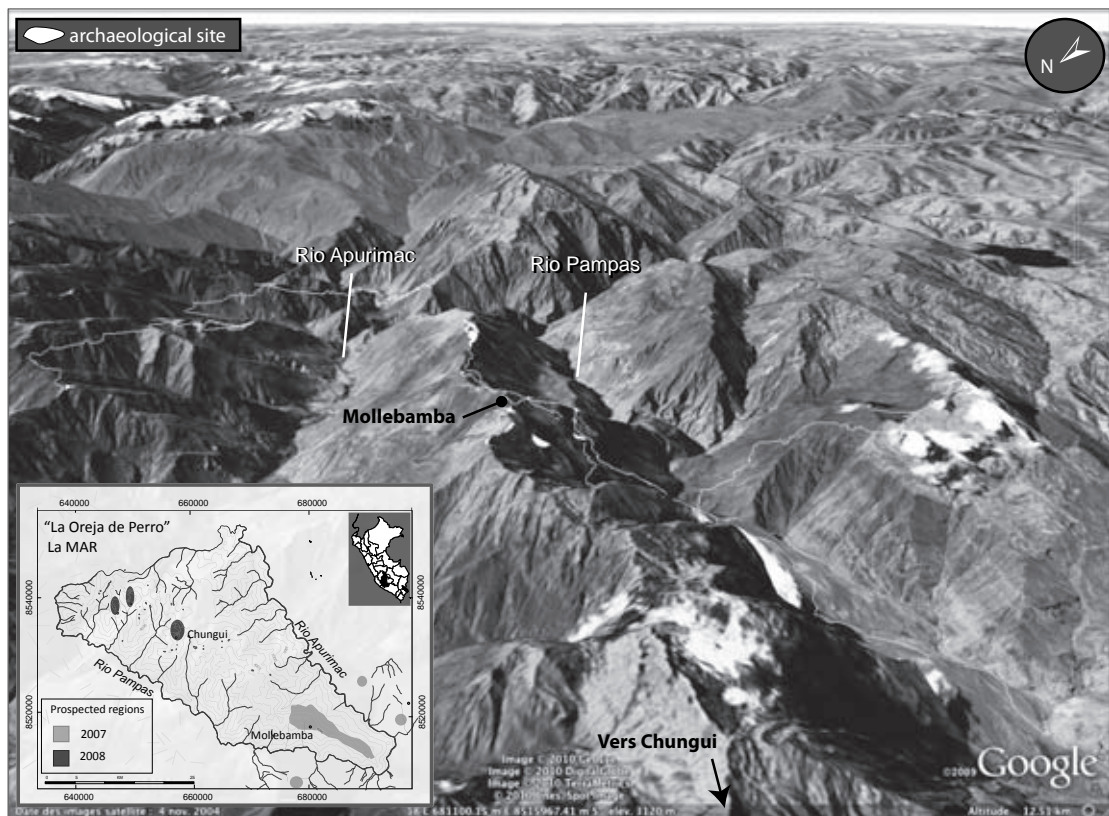
## KEYWORDS

*prospection, Google Earth, GIS, spatial analysis, Chanka, settlement*

In the heart of the central Cordillera of the Andes in Peru, the region of Ayacucho displays a landscape of mountains and enclosed hot valleys with a great ecological diversity, which have been favourable to human settlement since the Archaic period 10,000 years ago (Mac Neish et al. 1983). After the formative period (500 BC to 200 AD), which is still little known, it is during the middle Horizon, between 500 and 1000 AD, that the region became the centre for the emergence and development of the Wari culture which spread across a large part of the central Andes (Isbell 1978, 2000). It was eventually occupied by warrior groups related to the Chanka in the 12th century, and these groups have left the most important number of traces in these areas. It was subsequently occupied by the Incas in the 14th century (Lumbreras 1975; Gonzalez Carré et al. 1987; Bauer 2010).

The Choquek'iraw Chanka project, begun in 2007, aims to understand the process that populated a province in this region – La Mar, locally called 'la Oreja de Perro', lying between 1,000 and 4,500m above sea level, at the western end of the department of Ayacucho and 130 km west of Cuzco and the famous Ma-

Figure 1. 3 D satellite image showing the study zone, taken from Google Earth.



chu Picchu (fig. 1). It follows the excavations done from 2003 to 2006 on the site of Choqek'iraw in order to determine the nature and age of its occupation (Lecoq 2007, 2008).

The study zone's extremely steep relief and limited – if not non-existent – road network make access to this region very difficult. In addition, up till a few years ago the presence of armed groups, successors of the Maoist guerrilla group, *Sendero Luminoso* (*Shining Path*), and associated with drug traffickers, made it a dangerous region where it was difficult to go far from the towns to study or excavate the existing archaeological sites. What is more, most of the IGN (*Instituto Geográfico Nacional*) maps are still incomplete, not having been verified in the field by cartographers, and there are only a few aerial photographs of the area available.

These difficulties are at the origin of the methodology adopted for surveying 'la Oreja de Perro' – consisting of using high resolution satellite imagery from Google Earth to prepare the field work, and developing a DataBase Management System (DBMS) and Geographic Information System (GIS); the first time such an approach has been envisaged for Peru.

The limited time available for field surveys – only possible during three weeks in the summer university holidays and having to overcome formidable logistics problems – is another reason for the methods used.

## THE STUDY CONTEXT

The province of La Mar is a mountainous, particularly steep region extending between the beds of the ríos Pampas in the south and Apurimac in the north. The average altitude is 3,000m, but there is a steep gradient. The elevation at the valley bottom is 1,200m, which rises within a few kilometres to more than 4,000m at the top of the mountains. The existence of the two valleys, but also their situation on the line dividing the Andean highlands from the Amazonian lowlands, make this sector ideal as a place for understanding how it was populated. The group(s) who lived there must have tried to control several ecological levels – especially the Amazonian piedmont – as well as the communication axes such as the valleys of the ríos Pampas and Apurimac. But these valleys were probably more than mere thoroughfares from one region to another. There are good reasons for thinking that during the Late Intermediate period, in the 12th century and at the moment of Inca expansion from the 14th, these regions were also the main occupation centres for various ethnic groups, Chanka for example (Rostworowski 2001[2008]; Bauer 2010) – a hypothesis to be checked in the field. The surveying work, effected by M. Saintenoy, former VSI (International Solidarity Volunteer) at the French Institute of Andean Studies, while working on his doctoral thesis, on the northern bank of the río Apurimac should very shortly cast new light on the occupation of this valley.

## ANTECEDENTS AND METHODOLOGY: FROM SATELLITE IMAGES TO ON-THE-GROUND SURVEY

The archaeological data relating to the region are rare, mainly dating from the 1970s, before the emergence of the *Sendero Luminoso* prevented field research. They are due in particular to researchers such as Grossmann (1967), Scott (1972), Lumbreras (1975) and Isbell (1978), who identified formative tradition

occupations, Wari and Chanka, in various sectors of the valley. In 1987, González Carré, Pozzi-Scot and Vivanco (Gonzalez Carré et al. 1987) outlined a map showing the distribution of Chanka sites at Ayacucho, sites characterised by the presence of domestic structures with a circular plan.

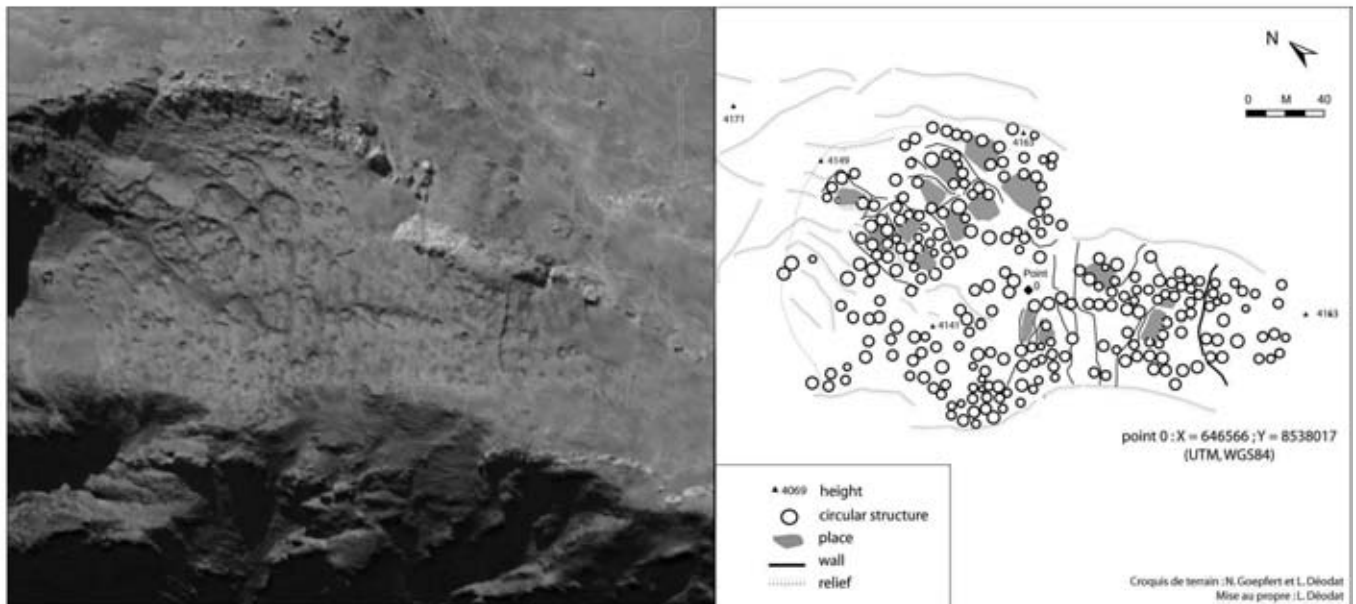
So, in 2007 and 2008, the project Choquek'iraw Chanka began, with two prospecting campaigns in this region, in close collaboration with the University of San Cristobal de Huamanga of Ayacucho and financial support from the French Ministry of Foreign Affairs.

The first campaign focused on the confluence of the *ríos* Pampas and Apurimac, the second on the vicinity of Chungui, the regional centre, some 60 km farther to the west. The aim in both these sectors was to bring to light archaeological sites of all types and periods. We decided to define a 'site' either as a major concentration of archaeological material, generally ceramic, or as an isolated structure or group of structures of varied character. Consideration was also given to all the paths, probably ancient, of which certain sections were constructed (retaining wall and paving; Hyslop 1984).

To succeed, the chosen prospecting method used all the available resources, in particular exploiting high resolution satellite images collected by Google Earth, topographic mapping, and collecting information orally from the local population. These three types of data then oriented exploration on foot in this craggy region, where systematic prospecting was impossible – the very rough relief and the dangers associated with the presence of groups of armed rebels limited walking expeditions dramatically.

The exceptional quality of the satellite images Google Earth (fig. 2) supplied for a large part of the surveyed region – giving very high quality close-up images up to a scale of 1/1000th – has enabled us to locate eleven sites and a set of paths actually before even arriving on the spot; the lack of strong vegetation in our zones of study facilitated the surveying. There are two sets of images for our study area, dated 17 and 28 June 2005 respectively, both belonging to the GeoEye company; the pictures were probably taken by the Ikonos satellite, at a spatial resolution of 0.82 x 3.2 m. Interpretative sketches of sites were then obtained from these very images. The structures clearly identified with recognisable forms have been indicated with unbroken lines; dots were used to represent the uncertain forms. This preliminary photo-interpretation work supplied relatively precise sketches of sites whose functions could now be suggested.

Figure 2. The site of Corral Corral, a village. Google Earth satellite image (left) and its interpretation (right), with sketches of the refined image made on the ground.



The forms that were delineated – essentially circles – belonged to structures already known from previous research: we had in front of us several villages made up of houses with circular plans, associated with plot boundaries and sometimes surrounded by outer walls. On each sketch, strategic points were targeted to obtain their geographic co-ordinates on Google Earth before being entered on the GPS, so as to facilitate their localisation in the field surveying. The GPS used, a Garmin 60CX, has an accuracy of 2m in the best of cases. All that was needed in the field was to follow the GPS to find the sites and carry out a classic survey on foot.

For each site discovered, several procedures were carried out in parallel:

- A series of GPS points were logged: in the centre of some structures, at each wall-end, in the centre of certain public spaces and on all the boundary of the site; the measurements were done using UTM projection coordinates and WGS 84 geodetic system. This *tracking*, systematically done, made it possible to define the sites and to calculate their area and perimeter. *Tracking* is a GPS procedure: when moving, the GPS automatically traces your route by logging a multitude of points.
- Site information sheets with six categories of data – general characteristics, location, geographic situation, site description, archaeological interpretation and equipment – were completed. A few structures – depending on their interest, their state of preservation, and their comparative originality – were also given a detailed description on a specially designed sheet. Sketches (plan and cross-section) and photos accompany each structure and each site sheet. These information sheets were done using the DBMS FileMaker Pro 8.5.
- The site sketches were either drawings made on site, or plans developed through photo-interpretation from satellite images retaken and completed in the field. In this way all the visible structures were represented, while recording the position of doors and other details. When it seemed of interest a cross-section complemented these sketched plans, which turned out to be very useful as these outlines assemble a great deal of information: the natural lie of the land, the organisation of the structures in relation to the dip with visibility of the artificial terraces built to level the spaces, and dimensions of the structures themselves. Let it be noted, the sketches made from photo-interpretation have proved to be relatively accurate in the light of on-site observation, and the errors in interpreting the satellite images were minimal.
- Ceramic and lithic material were taken from each of the sites we examined, and were then studied in the laboratory to improve the precision of the relative dating and to establish a chronological framework for the whole region.

It can be considered today that using Google Earth to survey such an isolated and dangerous region has saved a lot of time for two essential reasons. First of all, it has made it possible to detect sites and develop sketches before surveying on the ground, and next, to speed up the long work normally necessary with the local population to collect information on sites that may be located near the communities they come from.

Nevertheless, these satellite images cannot be used as a substitute for traditional surveying methods for the simple reason they do not enable all types of sites to be detected. On the photos only villages or sufficiently important ceremonial centres can be made out by a reasonably trained eye. On the other

hand, funerary sites remain invisible on satellite images, which is also the case for all the other smaller sites or those reduced to a simple concentration of archaeological material. We have only been able to discover this kind of site thanks to the local population.

Last but not least, even though this tool has allowed relatively precise plans to be drawn up, it is still unable to go into the finest details. Thus, reconnaissance on the ground has proved essential, not just for checking the data gathered and improving the plans, but also for taking away the archaeological material (ceramic, lithic etc.) needed to identify each site's period or function.

Google Earth should therefore be considered as a tool with a triple function:

- Detection of sites thanks to high resolution satellite images (Madry 2006; Garrison et al. 2008; Goossens et al. 2008), of the same type as aerial photographs (Deletang 1999);
- Data storage – since it makes data collecting possible;
- Sharing, since it facilitates the instant transmission of all available data to other users, via the Internet (Conroy et al. 2008).

It is an extra tool for archaeologists to use in developing surveying strategies, to be used parallel with other more traditional methods (Ferdrière & Zadore-Rio 1986; Jung 1998; De Laet et al. 2007).

## **RESULTS**

### ***Regional occupation and identification of ethnic groups***

The data obtained through these surveys show an important occupation of the region that began in the Andean formative period, between 500 BC and 200 AD, and continued up to the Inca period. In all, 46 sites were discovered in two years.

### ***The Formative period***

Two sites from this period (CC08-14 and CC07-1) have been located; they correspond to concentrations of ceramics scattered across the fields on the upper and middle slopes of the río Pampas at the limit of the middle valleys between 1,800 and 3,000m. They also include vestiges of agricultural terraces and/or other structures difficult to characterise, possibly connected to the culture of maize and tubers of potato type (*oca*, *mashua* etc.).

### ***The Middle Horizon***

The regional occupation continued during the Middle Horizon (600 to 1000 AD), characterised by a Wari tradition site located in the same biotope. The only site attributable to this period (CC08-13) is positioned at the confluence of two watercourses on the lower slopes of a hill. The site comprises the remains of a structure with a circular plan (5m in diameter) to which a dozen circular cists ( $\pm$  1-1.20m in diameter) are associated, constructed with randomly selected stones, and spaced at 1 to 1.50m. These types of varying depth cist burials are typical of the Wari and Tiwanaku cultures that flourished during the Middle Horizon, when they were generally placed near inhabited sectors – most often next to water courses, as is the case here, for ideological and ritual reasons.

### ***The Late Intermediate period***

The following period, called Late Intermediate, extending in the Andes from 1000 to 1400 AD, was heavily settled with 34 listed sites. These were generally fortified villages (29 sites), called *pucara*, characteristic of the settlements of the Late Intermediate period in the central and southern Andes, which left a deep mark on the landscape and are quite visible on Google Earth images or the available aerial photos (fig. 3). Veritable eagle's nests at the tops of cliffs and crest lines in the main regional massifs, they are evidence of a large population together with the strategic role that this out-of-the-way region appears to have had (Lumbreras 1975; Gonzalez Carre et al. 1987; Vivanco 2005). From these beetling citadels, apparently multifunctional – both defensive and ritual – it was easy for the inhabitants to overlook all their territory and most especially the ríos Pampas and Apurimac. Certain villages seem to have had, in addition, a defensive system consisting of walls and ditches. They include circular planned structures, 4 to 6m in diameter, often placed one against the other. When the villages were built on mountain sides or strongly sloping lines of crests, small terraces supported by walls had to be constructed to build the houses on level ground. These circular structures were organised around more or less cramped squares or esplanades with, in this case, their doors systematically opening into the square.

Frequently, these constructions had only one room, with a single entrance and a beaten-earth floor. The walls, 45 to 60cm thick, were made of ungraded large limestone stones often very roughly hewn, or of

Figure 3. The site of Corral Corral, a village with characteristic circular structures. *See for the full colour version also the front cover of this book*



blocks of basalt, piled up more or less regularly on the ground or on a bed of rubble. They were faced on both sides, and the central interval was filled with chippings, sometimes with earth mortar.

On certain sites (CCo8-1 and 6) walls – probably folds for animals or boundaries for fields – are noted. Nearby remains of agricultural terraces, old paths – difficult to date owing to their constant use by the local population – and simple or multiple burials under rock shelters (8 tombs listed) are also found. Small stone funerary constructions, of *chullpa* type, typical of the Late Intermediate period, could also be included (CCo7-3). These sites are generally attributed to very warlike regional groups associated with the Chanka and seemingly originating from the Amazonian piedmont.

### **The Inca period**

The Inca occupation – marking the beginning of the Late Horizon and extending in the Andes from 1438 to 1532 AD – does not seem to have had much effect on the regional landscape. Five sites date from this period and Inca material is found in a few villages of the previous period. The Incas seem to have been content to subjugate and control most of the Chanka villages, occupy some strategic positions, and develop the road network. Only the construction of ceremonial complexes, of *ushnu* type, seems to have transformed the landscape in any way (fig. 4).

These *ushnu* – still not clearly dated – are platforms, more or less complex, located on the summits of massifs, probably connected to mountain cults and star-gazing (Martinez 1976; Reinhard 2002). Two of these sites – one of which can be seen on the satellite images – are clearly attributable to the Incas (Zuidema 1980).

The first (CCo8-5), located at 4,200m altitude, consists of a set of three platforms, about 20.10m x 19.80m and 1.20m high, surrounded by a large wall open to the east formed of well-squared stones perfectly fitting together. The monument is oriented to the north-east and towards the peak of a great massif – which attests to the decisive role of the surrounding mountains (fig. 5). It is dominated to the south by a rocky spur and to the north-east by another important massif with a singularly tapering profile, both nowadays considered locally sacred as receptacles for the spirits of the ancestors – the *Apu*. The rest of the site includes diverse circular structures partly protected to the north and north-west by a large wall; these structures pre-date the *ushnu*, as they were destroyed by it.

The second *ushnu* (CCo8-11) shows much the same configuration. Located at 4,280m, on a rocky

Figure 4. Ceremonial centre or *ushnu* (CCo8-11).



Figure 5. Choquezafra glacier and surrounding area, visible from the *ushnu* (CCo8-11).



spur dominating the whole region, it is based on an ancient circular structure and comprises two platforms, one on top of the other. Here again the main façade is oriented to the north-east and the snowy peaks of the Choquesafrá massif, 36 km away beyond the Apurímac valley. Yet again, this ceremonial edifice is located on a crest-line right between the highlands and lowlands of the Amazonian piedmont and close to an ancient path – a particularity of most of the listed *ushnu* in other regions of Ayacucho and the Andes (Vivanco 2004; Meddens et al. 2008).

In both cases it appears that circular structures had been built by Chanka settlers before the Inca *ushnu*, since they were destroyed by it, as if the Incas had wanted to mark the landscape durably and thereby establish themselves in the region at several strategic points. Where no Inca *ushnu* was built, nevertheless, Inca tradition villages with rectangular structures are found beside the villages with circular structures (3 sites).

## DATA INTERPRETATION

### **The tools**

An issue inherent to a study of this kind, carried out on a micro-regional scale, is the concept of choice of settlement. How, and according to what criteria, do a group of people decide at a given moment to settle in a particular place? These are the criteria that archaeologists working on spatial analysis seek to identify. The use of GIS made it easier to envisage and analyse factors as varied as the nature of the terrain, the slopes, their orientations, the various ecological levels and the capacities the various sites had to observe one another. All of these factors had to be taken into account, and were integrated into a global synthesis. This is why – right from the start – integrating the data into a GIS appeared essential in order to effect this

analysis of how the space was occupied. Accordingly, topographic, geological and ecological maps were integrated into the GIS so as to superimpose all our data on these maps. Furthermore, a digital terrain model (DTM) – a representation of the topography of a given zone of the Earth's surface accurate to 90m – was downloaded from the NASA site: <http://srtm.csi.cgiar.org>. This DTM enables very interesting spatial analyses to be generated within the GIS.

### ***The different patterns of land occupation (fig. 6)***

Out of the 35 villages identified, 28 were built at an altitude of more than 3,000m; 17 at more than 4,000m. Altitude, then, was the essential criterion governing the choice of site. This systematic predilection for commanding heights – which is not limited to our micro-region, as numerous previous studies have already shown, such as those on the Asto settlements to the north of the region studied (Lavallée & Julien 1973) or those concerning the region Intersalar, in Bolivia (Lecoq 1999) – must not obscure the need for the minimal vital necessities: water, food, wood for fuel, building materials, etc.

The presence of rocky outcrops, abundant in the zones surveyed (essentially sedimentary rocks such as limestone and some volcanic stones) allowed the populations to use local materials to build their houses. They did not have to bring in stones from elsewhere, which made it easier for them to occupy these isolated sites. Only the materials used for making a few objects, such as hand mills, may have been transported over a few kilometres.

Concerning water needs, the Chungui zone does not lack lagoons, nor small streams; the Mollebamba zone, on the other hand, is more arid. Some springs however, well known to the present inhabitants, exist close to the sites discovered. These springs probably existed in the Late Intermediate, although this is not certain.

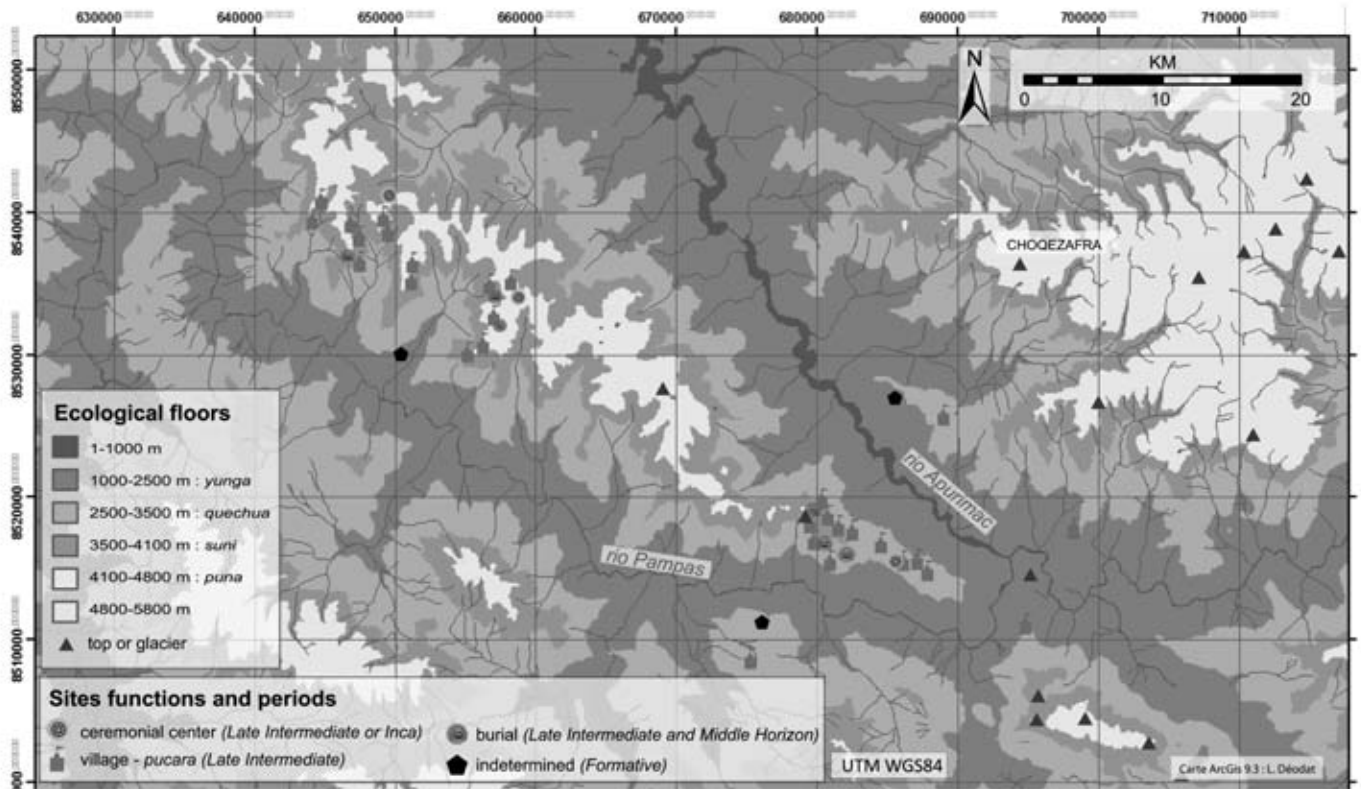
If today the vegetation of the zones in which the sites are situated are almost deserts – the present inhabitants travel several kilometres to get the wood they need for cooking – without any precise research, it is still hard to imagine what the vegetation was like in the early periods. Data collected by A.J. Chepston (2009) from cores taken from a dry lagoon in the Cuzco region at 3,350m, all show the same: from circa 1100 AD (Late Intermediate) – following a long, cold and relatively dry period – temperatures rose considerably and precipitation was heavier, making it easier for vegetation to grow. These factors seem to have allowed populations to settle at high altitudes, on territory which until then was uninhabitable, to develop these new plots by growing potatoes or quinoa. The villages' circular structure fits into this scheme perfectly.

Moreover, ArcGIS software enables us to create maps of classes of slopes based on the DTM. When the sites listed in the two surveyed regions are superimposed on this map, it quickly becomes apparent that all the village sites – with or without ceremonial centre – are placed on slopes of less than 10°.

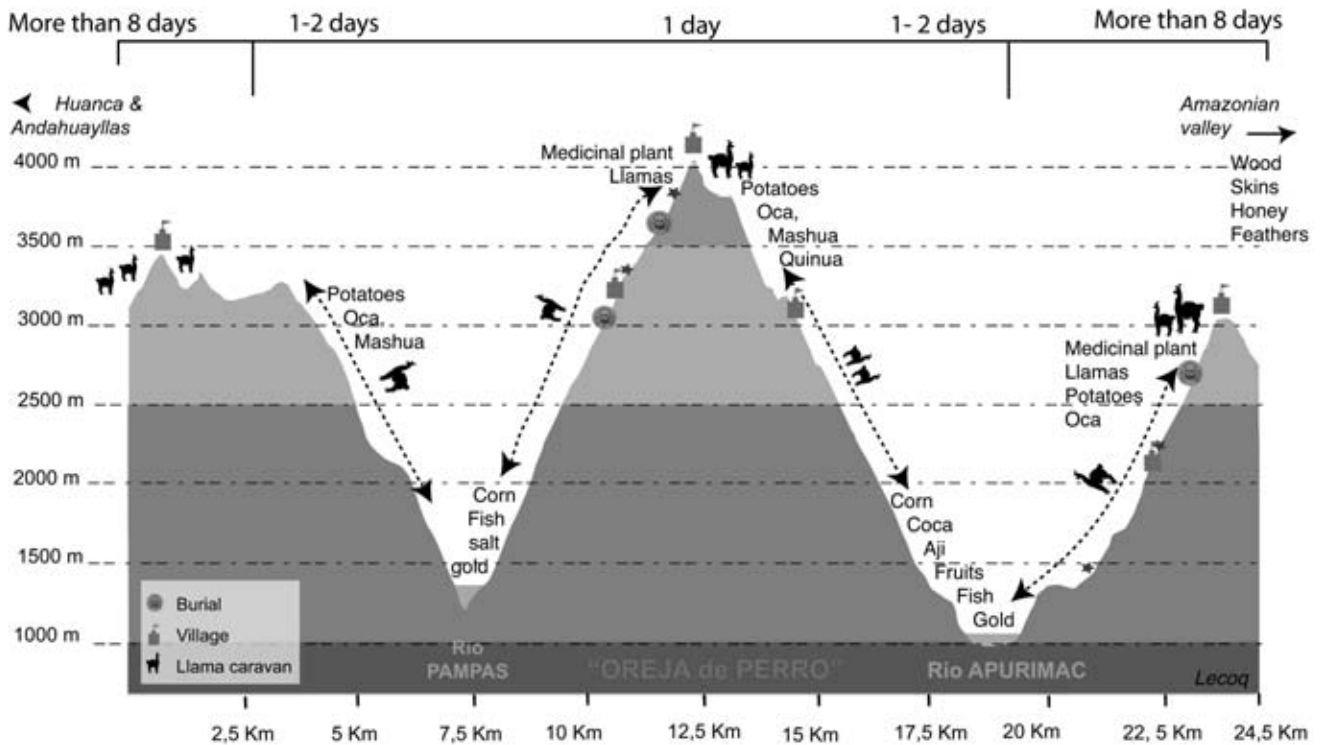
All these data are very helpful for understanding how the sites were occupied. Thus it appears that the inhabitants of these villages favoured the crests, in altitude, and also preferred fairly flat zones, which was not so simple given the rugged nature of the terrain throughout the region. The occupation zones were therefore quite restricted in the last analysis – if all the necessary, or even indispensable, occupation

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Figure 6. Localisation of sites in relation with ecological floors, extracted from GIS. See also the full colour section in this book



The schematic drawing above shows the different floors of the Andes and their ecological resources. It also indicates the barter system in which llamas or mule caravans are used to transport products between zones. Archaeological sites of the Formative period are located in the lowlands and the fertile ecological floor (Yunga). Villages of the Late Intermediate are located in the highlands (Suni, Puna and top of the Quechua zone).



criteria are summed up: elevated zone for keeping watch and defence, flat space for ease of construction, rocky outcrop for construction materials, and proximity to springs or a stream for vital needs. As for food resources, another parameter must be taken into account – the ecological levels.

**The ecological levels: an anthropological approach (fig. 6)**

In the Andes, the ecological levels play a very important role, which had to be taken into account. To take full advantage of varied resources each community sought to exploit various ecological levels. This particular exploitation of space, dating from the Pre-Hispanic period, has been defined as ‘verticality’ by the American anthropologist Murra in 1975.

Accordingly, we created a map showing the various levels of the zone studied, using as a reference the work that Pulgar Vidal proposed in 1941 (Pulgar Vidal 1996) on the eight natural regions of Peru, taken partly from those developed by Morlon (1992, 122-202). Each ecological level has its own characteristics – climate, fauna, flora, soil types – which affect how the land is exploited – agriculture or pastoralism – and the vegetable and tree varieties cultivated, which may be summed up as follows:

- 500 to 1,000m, generally the domain of the forest, where coca, cocoa and coffee are exploited. This level has been defined as coastal (or *challa*) on the Pacific littoral or low and high *selva* (*omagua* and *ruparupa*) on the eastern foothills of the Andes.
- 1,000 to 2,500m, on the Yunga fluvial level valleys, with a hot, dry climate are found, suitable for fruit trees such as orange, lemon and avocado. The natural vegetation is shrub and forest.
- 2,500 to 3,500m, or Quechua level, the slopes bordering the valleys are highly suitable for agriculture, which is why most of the population today lives on this ecological level, which has given its name to the language (Quechua) of the populations living there. Maize, wheat, quinoa, tomatoes, squash, etc. are cultivated on terraces. Fruits such as the papaya and pomegranate are also grown. Some trees grow naturally in this region: the *molle*, and the eucalyptus (though the latter was introduced after the conquest).
- 3,500 to 4,100m, *Suni* level, a zone with a temperate to cold climate is found with a very rough relief and many ravines and small enclosed valleys. This is the realm of the tubers with their countless varieties (*oca*, *masua*, *papa*, etc.), which are cultivated traditionally with the digging stick or *chaquitaclla* (Morlon et al. 1992). This is also the region, near streams and springs, where *tunta* and *chuño* – dehydrated potatoes – are prepared. Vegetation here is essentially shrub with various prickly plants, as well as dwarf trees.
- 4,100 to 4,800m, the *Puna* stage, corresponds to a mountain desert region, with a shallow arable layer and a very cold climate. Not very suitable for agriculture, the vast natural pastures covered with grass like the *ichu* (*Poaceae*, *stipa Ichu*) found here are therefore used for livestock.
- Above 4,800m, the pastures give way to the high mountains and glaciers – often considered sacred. Human occupation is generally limited to a few high altitude sanctuaries.

It may be observed that all Late Intermediate sites, attributable to the Chanka and Inca groups, are located in the Quechua (8 sites) *Suni* (15) and *Puna* (11) regions, between 2,500 and 4,500m altitude – with a large majority above 3,500m.

The Andean verticality model fits the region especially well, where today each community still pos-

sesses a parcelled out space, adapted to the various ecological levels it controls. This space extends along the Ríos Pampas and Apurímac until the Amazonian piedmont, and probably the same was the case in the Pre-Hispanic era, even if this is difficult to determine. It should be made clear that the world of the Puna may only have started at 4,300m – according to D. Lavallée (Lavallée & Julien 1973, 86) – which increases the arable land surface area considerably. Now, 8 sites are located precisely between 4,100 and 4,300m, which is hardly significant; for depending on their level, they would have been turned towards either pastoralism or tuber growing. Unfortunately, we still lack precise local data on this subject. We can, nonetheless, sum up the situation as follows: the 8 villages in the *Quechua* zone could have a wide and varied diet of vegetables and cereal; the 15 villages in the *Suni* region seem to have oriented their activities mainly towards tuber growing, and the 11 in the *Puna* region probably devoted themselves to stock-rearing. It is tempting to imagine systems of exchanges between all and sundry, and even to suppose two villages distinct in space may have formed a single community.

Numerous questions are still to be answered. We have no example of a village located in the lower levels, especially favourable for fruit groves. That said, we suppose the villages discovered corresponded to their ‘urban centre’ and that in the other levels, as is the case today, the inhabitants only had a few sheds of perishable materials next to their fields and/or groves, types of remains difficult to detect when prospecting on foot. Cores perhaps should be considered, in places suitable for farming for instance, in the hope of finding vestiges of these temporary occupations.

Another aspect raises some issues concerning the sites located above 3,500m altitude: why establish the ‘administrative’ centre of a region, or of an ethnic group (if such is the case) at such an elevated altitude, far away from the resources in the valley, instead of ‘in the middle’ so as to be at an equal distance from the resources of the *Yunga* and *Puna* levels? The modern village of Mollebamba offers a good example of the efficient exploitation of the levels. Its inhabitants live in the main hamlet at 3,000m, where they can cultivate maize and all sorts of vegetables; they also have a house at 4,000m to produce many varieties of tubers and keep animals; lastly, they possess a few fruit-trees (e.g. orange and lemon) at 1,000m in the valley.

Now most of the villagers in the Late Intermediate lived in very out-of-the-way places, which seems to suggest the principal factor behind the choice of sites was not the availability of varied resources – the inhabitants being quite content with a meat-tuber diet – but rather a need for defence and control. One argument tends to strengthen these hypotheses, and it concerns fields of view.

### ***Fields of view, inter-visibility (fig. 7)***

DTM allows work on notions of fields of view, and thus fosters more profound spatial and three-dimensional thinking. The software can be asked to draw all the zones visible from a precise point, so visibility maps can be created for each site so as to define several parameters:

- Inter-site visibilities, which allows an approach to notions of inter-population relations or even relations of domination and submission between different sites that may have belonged to two ethnic groups, for example.
- The zones visible from a site, such as glaciers and other sacred mountains or *Apu* and the water courses – which opens a door into the ritual world of these cultures.

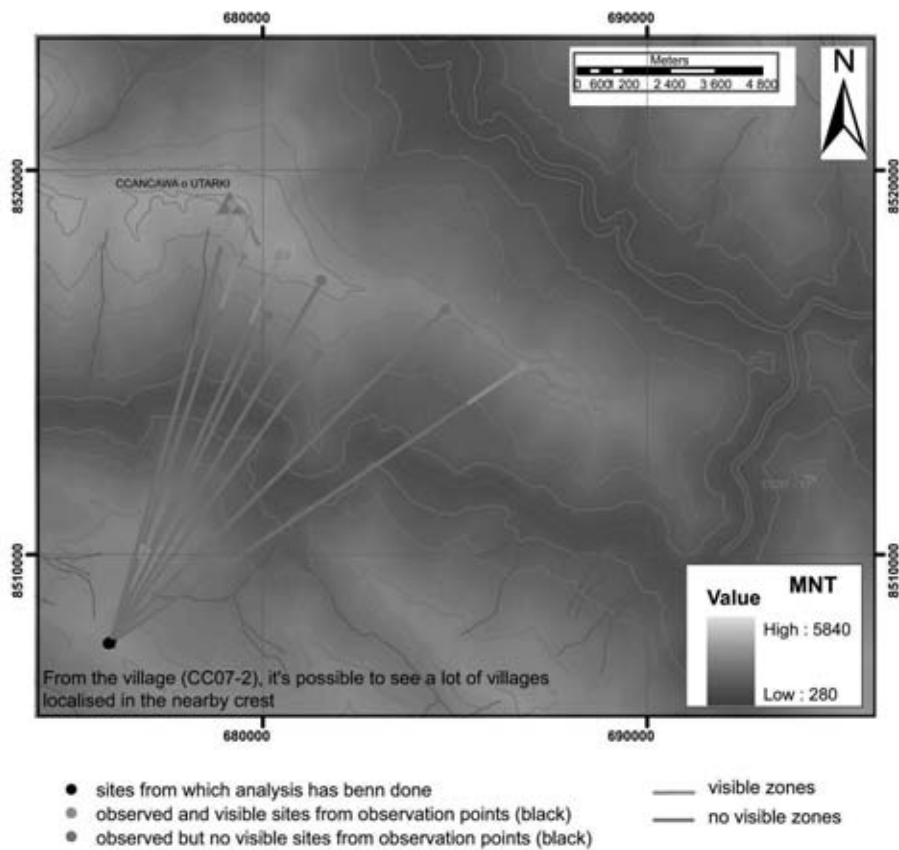
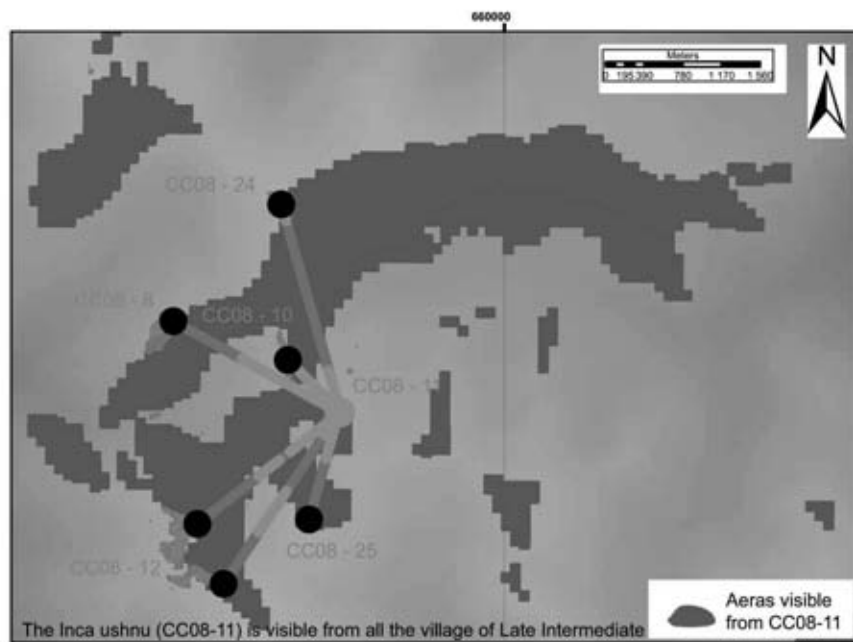


Figure 7. Example of visibility analyses between two or more sites, extracted from GIS. See also the full colour section in this book



This type of analysis was carried out for all the Late Intermediate villages, and the map presented here (fig. 8) shows the results for four quite different sites. It should be noted that the analyses were done within a range of 300 km around each site, and that a certain number of tests were first carried out and considered

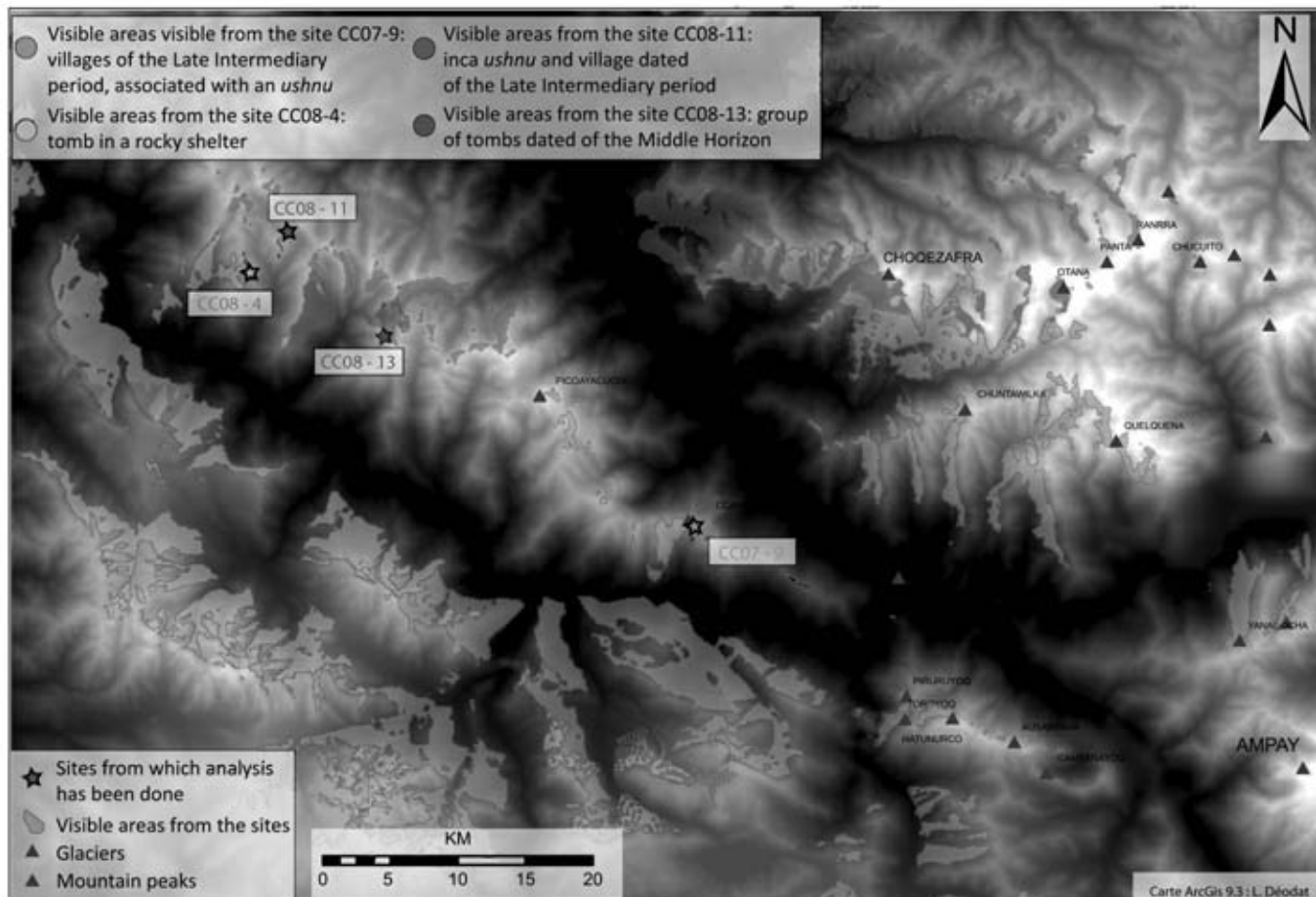


Figure 8. Visibility map based on a DTM, extracted from GIS. See also the full colour section in this book

together with our field notes and the topographic maps before defining a rigorous method. The examples chosen allow the method to be validated, while considering a sample of sites with different functions and chronologies: villages, ceremonial centres, tombs belonging to the Middle Horizon and the Late Intermediate period.

The first site to attract attention, because it offers a perspective of 360°, is a ceremonial platform or *ushnu* (site CC08-11) from which it is possible to observe one of the most important glaciers of the region: the Choquesafrá. Site CC07-9, which is an elevated village with a small ceremonial platform at its highest point, offers a good perspective too, with (yet again) a wide view of the Choquesafrá but also of a large part of the Pampas valley. From site CC08-4, which is a tomb arranged in a rocky crevice, probably associated with the village CC08-6 some tens of metres above, a good view is obviously to be had over the whole south-west zone (since the site is built against a cliff on the north-east side) and therefore over the Rio Pampas. Lastly, from site CC08-13, which is a group of Middle Horizon tombs, the perspective is evidently non-existent – except for a few summits in the immediate vicinity – which goes to show that visibility was not necessarily looked for in this site's position. Those who chose it probably did so because of the confluence of two small streams about 50m below, which was a decisive criterion for locating necropolises and other tombs of this period throughout the central and southern Andes (Lecoq 1999, chapter VI).

The negative result, as far as this site is concerned, reinforces the importance of visibility for the Late Intermediate villages – whether fortified or not, with or without ceremonial centre: during this period people settled in places where they could keep an eye on their neighbours and the communication routes and see the principal *Apu*.

## CONCLUSIONS

All these data help us to understand better what could push people to prefer settling at one site rather than another. Strictly based on archaeological evidence, the populations living at between 3,500 and 4,500m either had extensive pastures and consequently abundant meat, or a large variety of tubers; exchanges may have existed between the ones and the others. At the same time, living this way in the high places made it possible to overlook and monitor a large part of the surrounding territory, as well as coming under the protection of the *Apu* (the sacred mountains) that could be seen from most of the sites. As for the villages between 2,500 and 3,500m, their inhabitants had more varied agricultural resources but less visibility. Possessing lands at other ecological levels, they may well have had a greater variety of resources, but this remains to be proven, archaeologically speaking, since no trace of Late Intermediate occupation below 2,500m has been found (except for site CCo7-19).

Moreover, if these results concerning modes of settlement were proven, they could be used in the future as new criteria for detecting the presence of sites. Numerous parameters would then be available, when reading a map, for suggesting zones to survey that are more likely to contain undiscovered sites. For the Late Intermediate period this would mean, for instance, crest zones above 2,500m with slopes of less than 10°. That said, it is also indispensable to survey the low zones more systematically, in order to have more chances of discovering other types of sites of the same period at these altitudes.

Be that as it may, the Google Earth satellite images have proved to be prospecting tools of prime importance, and spatial analysis has made it possible to define how sites were settled and so better understand the populations we are interested in. These methods – still little used in the Peruvian Andes – offer very promising prospects for the future.

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