

Interactive comment on “Putting the rise of the Inca Empire within a climatic and land management context” by A. J. Chepstow-Lusty et al.

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Reply to second reviewer

We thank the reviewer for a set of detailed, authoritative and perceptive comments, most of which relate to the archaeological aspects of the paper. Where appropriate, changes will be incorporated into the revised manuscript, as detailed variously below. Reviewer comments are here dealt with in turn (where appropriate, these are repeated in bold).

General Comments

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We acknowledge and appreciate the positive remarks that the reviewer makes with regard to the ambition and scope of the paper. With respect to concerns over the depth of the archaeological component of the study, we would stress that the manuscript is aimed chiefly at a broad audience and seeks to present a combined synthesis of results across a range of disciplines. This paper is not intended to be a specialised, archaeologically-focused study, therefore, but it is our intention to incorporate these results into a future article that will have a distinct and specific archaeological remit.

To this end, we believe that we have shown awareness of the societal complexities and strategies relating to our environmental interpretation, but at the same time reserve the right to maintain our basic assertion that increased crop productivity, supported by warmer conditions, underpinned societal development in the region (particularly agricultural manipulation of higher altitudes above the Sacred Valley). Indeed, we have not sought to portray our interpretations as either simplistic neo-environmental determinism or as reflecting an essentially ‘green’ approach on the part of the Inca, but have instead tried (within the constraints and scope of the paper) to acknowledge some of the other factors at play that are interlinked with environmental change (including demographic and socio-political pressures).

Specific Comments

Introduction

“The ecology of human resource management as characterized in this introduction seems simplistic...” We refer you to the point made above concerning the scope of this paper and our unease with regard to neo-environmental determinism. Our stance remains the same – essentially that the Inca and their predecessors could not move up the valleys and properly exploit higher zones until temperatures had passed a certain threshold. This is the point at which innovative techniques, including re-shaping the landscape with largely glacial-fed irrigated agricultural terraces, could be employed. The Patacancha Valley is full of under-used or abandoned Inca terraces and was/is

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highly productive, and not just in terms of valley-bottom agriculture. To understand the scale and the economic importance of valleys such as the Patacancha in the past is to gauge the possible productivity of the terraces in the Ollantaytambo District, of which it formed a part; this has been estimated at almost 2,400 hectares of Inca and pre-Inca terraces, perhaps supporting 100,000 non-local people (Kendall, 1991). Such a major agricultural exploitation at these altitudes was only possible after AD 1100; prior to this (and certainly between AD 300-900) conditions were too cold for sustained agriculture, as evidenced by other environmental records from the region and the paucity of archeological records from this part of the Patacancha.

“I have seen the scant literature alleging the sustainability of Inka practices. . .” The reviewer makes a good point in this regard and we are in agreement. However, whilst we do not intend to suggest that the Inca were particularly ‘green’, we nevertheless maintain that they carried out practices that worked successfully (and sustainably) across a range of agro-ecological zones. Whilst these practices were in some cases innovative, they were also building on techniques developed by previous societies, such as the Wari. One such strategy was in spreading their risk – such as storing their surpluses for less productive years – as shown by the array of storehouses that still exist above Ollantaytambo today.

As to the deforestation issue, it is true that the Spanish described essentially bare hillsides with a few patches of trees; however, this was not necessarily entirely the result of human deforestation, as early-mid Holocene drought may have impeded forest growth, particularly in the higher altitudes, until the temperatures began to rise ca. 1000 years ago. There is also ample literature to show that the Inca protected their existing forest resources. Indeed, the Spanish chroniclers record the value of trees to Inca society (see Chepstow-Lusty and Winfield, 2000), both economically and in rituals. Furthermore, capital punishments were meted out on those who cut down trees illegally and certain quechua words for planting trees (as recorded in the 16th century dictionary of Holguin) equate with dead ancestors, demonstrating a reverence for trees.

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Similarly, there are many documents to show the rapid forest destruction instigated by the Spanish, whose demands were much greater, such as for manufacturing steel and tiles, baking bread, etc. (see Chepstow-Lusty and Winfield, 2000).

“. . .there is virtually nothing published on the Wari decline in the imperial heartland or other provincial region.” We concur that the example of Cerro Baúl may not be typical of the ‘collapse’ of the Wari as a whole and, furthermore, agree that little palaeoenvironmental work has (as yet) been carried out in the core areas of Wari occupation. For the final version of the manuscript, therefore, we will amend our discussion of this issue accordingly and also incorporate reference to a new (in press) study by Bauer and Kellett that addresses some of the reviewer’s concerns about evidence for shifting settlement patterns after AD 1000 to higher elevation sites.

“The coring work and analysis conducted at Marcacocha is indeed valuable, but whether it can be extrapolated onto the archaeological patterns of the Cusco region as a whole is another question.” (pp. 4-5) This is a fundamental concern of almost all studies conducted using a relatively small number of geographically-constrained palaeoenvironmental records. We would be the first to agree that additional lake sequences of a similar quality are required across the Inca heartland to build up a more complete environmental picture across this time period. However, until such time as those studies become available (work is ongoing by several groups – including ourselves – to achieve just this) we can say with certainty that Marcacocha is, nevertheless, a remarkable site, and for numerous reasons.

We have already demonstrated that the unusually well-preserved organic sediments that span 4000 years at sub-decadal resolution provide us with confidence in the sensitivity of the site to environmental change. Small lakes of this morphology and structure cannot form in the Sacred Valley or Cuzco Valley, as these altitudes are too low to create glacial features such as this. Secondly, whilst we agree from first-hand familiarity with the region that the valleys north of the Sacred Valley can be of very different character, the Patacancha can in no way be considered minor or marginal in impor-

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tance. The reviewer already acknowledges the location of the site with respect to a major trading route and the proximity of the important Inca settlement and fort/religious site of Ollantaytambo. The lake basin itself was considered sacred and, with the best pasture available in this part of the valley, is surrounded by Inca and pre-Inca terraces; is adjacent to the archaeological complex of Juchuy Aya Orqo (dating from ca. 700 BC); and is also overlooked by the hill-top site of Hatun Aya Orqo, with an Inca tambo below. There is even the proximity of the 5 km-long Pumamarca Canal to consider, situated above the fortress of the same name and supplying the extensive terraces of Choquebamba on the western side of the Patacancha Valley.

In terms of an economic focus on valley-bottom maize fields several hundred metres lower down, this was only part of the production in the Patacancha. There was significant maize production right up the valley to Marcacocha, which is located at the environmental boundary of maize and potato production (3350 m). This was a valley that was (re)designed to maximize agricultural production, a testament to which is the sheer number of abandoned and under-used Inca terraces present today. Furthermore, the importance and symbolism attached to maize production has probably disguised the calorific significance of potatoes and other tubers, which would have furnished a major dietary component for the local people. It was not, therefore, simply a question of maize or potatoes – the system was clearly designed so that different agro-ecological zones could be exploited for maximum benefit (in fact, probably to a greater extent than today).

Interpretation and Discussion

"The preceding observation – that Marcacocha may reflect the human transformation of a very specific and localized environment over time – raises some problems with the interpretation of research results" We believe that we have addressed this concern in the response given above.

"If this pollen reflects domesticated plants introduced to the area intentionally by hu-

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mans, then the paucity of such pollen would seem to reflect low human population densities, or a focus on other kinds of subsistence strategies (and not climatic conditions)." We would argue that, whilst low concentrations of Chenopodiaceae pollen (in part representing crops such as quinoa) do indeed suggest low human population densities, this evidence is not inconsistent with an environmental driver (i.e. that conditions were generally too cold to sustain significant populations at these altitudes). We have included the complete Marcacocha summary pollen record in the article to show the comparison with the period between 2200 BC-AD 200, when conditions would have been much more favourable for quinoa production; quinoa and closely related crops normally grow at higher altitudes than maize (such as on the Altiplano today) and require less water. We concur with the reviewer that Marcacocha would likely have been a site supporting other subsistence strategies (such as pastoralism – indicated by our mite record) at these times, because this area provided guaranteed grazing due to the permanently wet pasture around the lake. However, we believe that climate was still restricting human population expansion until after AD 1100.

As to earlier periods of settlement to which the reviewer refers (which are not the focus of this particular paper), we are in agreement with the demographic comments and will take up the suggestion to expand this slightly in the final version of the manuscript (including making reference to Steven Kosiba's recent work).

"I'm not sure how macrocharcoal levels can be taken as evidence of either agriculture or herding activities." (p.10) The reviewer raises an excellent point, and we will endeavour to provide further elaboration and clarification in the final manuscript. The relatively large charcoal particles (>125 μm) measured in the lake sediments are of a sufficient size to provide an indicator of very local burning, i.e. within 100-200 m of the lake – and the small size of the lake itself reinforces the local nature of these events. These charcoal particles are either washed into the lake by surface run-off or blown in, but their large size means that they have not travelled far. They are most likely to reflect human-derived burning activities, since fires caused by lightning are extremely

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rare in the Andes. However, although these are local events, it does not mean that they do not reflect much wider contemporaneous events, such as burning to clear a newly colonized landscape for agriculture, or seasonal burning in the dry season after harvesting or to improve the quality of grazing land. These activities are all seen in the Patacancha Valley today. We agree with the comment that domestic fire sources cannot be completely excluded, as Marcacocha is only 100 m from the archaeological site of Juchuy Aya Orqo (though this would be expected to be a minor source). In essence, it is the context in which the burning events occur, combined with other indicators in the sediments, that guides our interpretation as to whether they may be more related to agricultural practices or to maintaining the pasture (although the most immediate area of pasture around the lake probably remained wet and required minimum levels of maintenance).

“The authors seem to treat agriculture and herding as alternatives rather than elements of a single local or regional economy.” (p.10) This is not our intention, as we consider that, whilst both activities would likely occur concurrently to a greater or lesser extent, climatic conditions would determine which would be the most profitable (and therefore dominant) strategy. As mentioned previously, between AD 900 and 1100, grazing would probably dominate, as conditions were too cool for major agriculture. Subsequently, however, agriculture would be more important, with camelids being grazed at higher altitudes as the land around Marcacocha would have been too valuable. Animals might be brought in to exploit leftover plant resources after harvesting. However, during the Inca expansive phase (after AD 1400), commerce was important, with herds of llama caravans travelling between the sierra and the selva, and hence the pasture around the lake would once again have been a vital commodity for grazing.

“One problem with Marcacocha is that it is not the best location for agriculture. . .” This issue has been partly addressed above. Although Marcacocha does not have wide valley-bottom fields for generating large-scale maize production, it is surrounded by substantial terracing and has a permanent water supply from the Patacancha River.

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In Inca times, there were additional canals on both sides of the valley supplying melt-water to the surrounding terraces, including a canal directly to the site of Juchuy Aya Orqo, only 100 m away. Marcacocha is able to provide a mixed economy of maize, potatoes and other tubers, and good pasture has always been available by the lake. Frosts are very rare at this site today, which may be a function of the river alleviating extreme temperatures in this part of the valley (which is, in any case, almost completely sheltered by surrounding hills). The density of ruins and terraces, and the archaeological record of continual human occupation at the site for at least 2700 years (except for much of the first millennium), indicate that Marcacocha has continued to be a significant, exploitable resource.

“In the post-1532 discussion macrocharcoal is now taken as evidence of burning associated with pasturing European animals. . .” (p.12) A different world was imposed with the arrival of the Spanish. There was huge depopulation in the valley due to forced movement of people to encomiendas, the llama caravans disappeared (in fact the Spanish reported that two-thirds of the llamas in the Cuzco area died of skin diseases) and the canals used for irrigation around Marcacocha were not maintained and fell into disuse. We can only predict that under these circumstances, with a much lower population in this part of the valley, much of the previously cultivated landscape became rapidly overgrown. Nowadays, only a fraction of the terraces are used at any one time, and there is a long cycle of fallowing. A major part of the charcoal signal following the arrival of the Spanish probably represents the continual effort to clear the agricultural land from rapidly colonizing shrubs and herbs, as well as burning fields after animals have finished eating the stubble and other plant remains left after harvest.

“Seeking a broader context for the Marcacocha data is important, but this should include tighter control over the archaeological record.” (p.15) We would agree wholeheartedly with the reviewer that a tighter grasp and better understanding of the archaeological evidence is crucial for interpreting events. This must be achieved by the combination of a range of evidence, both palaeoenvironmental and archaeological. The

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Cuzco region is undoubtedly one of the richest archaeological regions of the world, yet most work in the region consists of excavations without any environmental component. Studies by a new generation of archaeologists (much of which has been referenced in this paper – e.g. by Bauer, Covey and, more recently, Kosiba) are gradually changing this situation. However, what is really needed in the Cuzco region is the type of approach carried out by Christine Hastorf and colleagues in the Mantaro area, which looked at the carbonised remains of crops and wood resources. This is an approach that would bring palaeoecology and archaeology closer together in the Cuzco area, as palaeoanthracology derived from a good stratified archaeological sequence can show directly what people were doing with their plant resources in situ. We are hoping that this paper will help to catalyse these kind of investigations.

Technical Corrections We will clarify and re-write the sentence referred to for the final version of the manuscript

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