KEYWORDS: ***Petroglyph - Age estimation- Stone tool - Bolivia***

SOME ANALYTICAL OBSERVATIONS OF BOLIVIAN ROCK ART

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Abstract: A Bolivian project commenced in 1987 and has so far resulted in estimates of antiquity of petroglyphs at six sites in various parts of the country. At five of these sites, microerosion was used to acquire data, and in three instances the work was set up as «blind test»: local archaeologists has some indication of what the age of the rock art might be, and this was announced to the analyst only after his results were given. In all three cases, the microerosion results coincided with archaeological estimates. At three of the sites, the microerosion data could not be obtained from the petroglyphs, because conditions were unsuitable, therefore petroglyph-making tools were collected and analysed instead. Consequently, in these cases the age estimates cannot be attributed to specific motifs. This is a new rock art dating approach not used before.

Introduction

This paper summarises some preliminary findings of a project I commenced in July 1987 (Bednarik, 1988, 1992a), with the close collaboration of Roy Querejazu Lewis, and which is still continuing over twenty years later. This research project has included a variety of methods: geomorphic studies, microerosion analyses both of petroglyphs and stone tools, nanostratigraphic excavation, chemical and petrological analyses of precipitates, patination studies and replication experiments. The purpose of this work was to provide an initial understanding of the rock art sequence at a series of Bolivian petroglyph sites, focusing most especially on one small but important site, Toro Muerto. This site is not to be confused with the very large petroglyph concentration at the Peruvian site of the same name, located in the Rio Majes valley. The results add new and relevant information to the rapidly expanding reliable data concerning the ages of the central Bolivian petroglyph traditions (Bednarik, 1997a, 1998a, 2000).

My interest in estimating the ages of South American petroglyphs stems from a major journey in 1987 to many South American rock art regions. One of the Bolivian petroglyph sites I visited then was Cabracancha, Departamento of Santa Cruz, which had just been discovered (Fig. 1). A microscopic examination led me to estimate the age of its markings to be between 500 and 1000 years, based on geomorphological indices. The petroglyphs at this small site are dominated by a distinctive 'trident' design, which is also prominent on ceramic remains in Bolivia. Such remains were subsequently excavated in a stratified context at another site, Comacho Tunal Mayu, where they occurred together with charcoal providing a radiocarbon age of 560 ± 70 year BP in 1996. This seems to confirm the estimate derived from 'direct' indices through a 'blind test'.

Another Bolivian site I first examined in 1987 was Toro Muerto, on the Mizque River. I determined

Figure 1. *Petroglyphs at Cabracancha, which on the basis of a microscopic study of their geomorphology were thought to be between 500 and 1000 years old; with Roy Querejazu Lewis on left, August 1987.*

that its numerous petroglyphs belonged to several discrete chronological groups but at the time remained unable to estimate the age of any of these traditions.

However, the first application of microerosion analysis in 1990 (in Russia; Bednarik, 1992b, 1993) opened up new opportunities in petroglyph dating. This cluster of methods is centred on a technique in which geometric indices of microscopic erosion of fractured mineral crystals are used to estimate the time of exposure. It is only applicable to certain rock types, and only if their exposure to weathering has not been impeded by mineral accretions, sediment cover or a sheltered position. Most importantly, it can only provide valid data if remnants of the original petroglyph surface have survived. This method has now been applied to rock art in most continents, in eleven countries. Six calibration curves have been secured so far, representing climates ranging from extremely arid (Saudi Arabia) to temperate and sub-alpine (northern Italy). Most importantly, it has been subjected to 'blind tests' at seven sites worldwide, two of which are located in Bolivia. Such 'blind tests' can be applied in cases where archaeological evidence is available that would favour a specific age of a particular petroglyph, but remains unknown to the analyst prior to announcing his results. Alternatively, a blind test may involve the application of another method of direct dating, or of several such methods, in which the various results are presented to an independent arbiter for comparison. In all seven cases worldwide, the microerosion data agreed completely with archaeological estimates or with the results derived from other methods by other analysts. Microerosion analysis is considered to be the most robust and reliable of all rock art dating methods, although it certainly lacks in precision, particularly in cases without proper calibration (Bednarik, 2002a).

Microerosion data are presently available from five Bolivian sites: Toro Muerto, Inca Huasi, Kalatrancani 1 and 3, and Lakatambo 2 (Table 1). At the last-named site, the result derived from a single cupule was E700 ± 150 years BP, and after this was announced in the field to the accompanying archaeologist (R. Querejazu Lewis), he disclosed that the large occupation site on which the petroglyph-covered boulder occurs dates from roughly 1200 C.E. The microerosion date was therefore apparently very accurate.

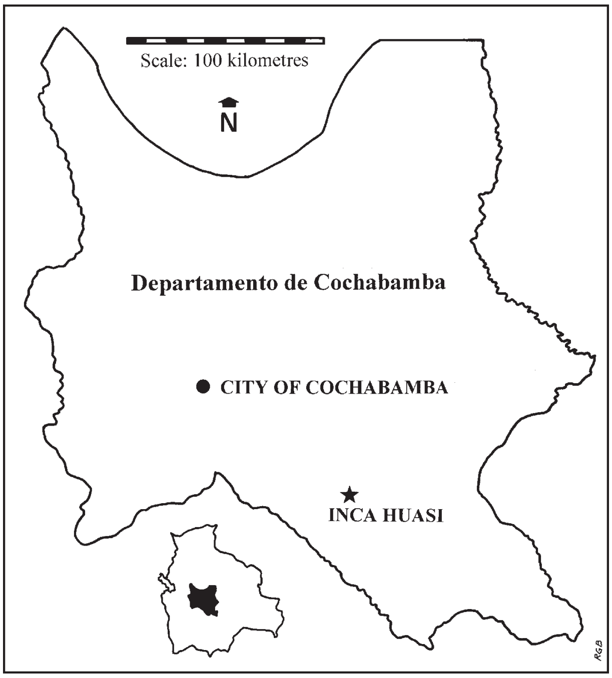

Figure 2. *Location of Inca Huasi (and other Mizque sites) in Bolivia.*

Inca Huasi

The second Bolivian site where a microerosion result was obtained under the conditions of a blind test was Inca Huasi, like Lakatambo located near the town of Mizque (Fig. 2). At Inca Huasi, three distinctive types of rock markings occur. The oldest are random cupules found on a metamorphosed sandstone dyke overlooking the site. This quartzite formation is greatly resistant to weathering and has protected a slope of softer sandstone from fluvial erosion by the Uyuchama River (Fig. 3). The soft sandstone slope bears much younger petroglyphs, consisting of simple geometric motifs such as circles and wave lines. This tradition includes also cupules, but these are almost invariably arranged geometrically, especially in lines. These petroglyphs appear fully repatinated, usually covered by a black deposit resembling a ferromanganeous accretion. Microscopic examination reveals, however, that this deposit consists of a very small lichen species.

In an area separate from these petroglyphs,

Site	Feature dated	Result
Inca Huasi (blind test)	Polished surface	E1028 ± 300 years BP
	Geometric petroglyph	Est. 4000–1500 years BP
	Cupules on quartzite	Earlier
Toro Muerto	Minimum of three traditions, est. 4000–500 years BP	
Lakatambo 2 (blind test)	Cupule	E700 ± 150 years BP
Kalatrancani 1	Single petroglyph hammerstone	Est. 700 years BP (tentative)
Kalatrancani 3	Chips from hammerstones	Est. 600–500 years BP (tentative)

Table 1. *Microerosion results from five Bolivian petroglyph sites.*

Figure 3. *The oldest cupules at Inca Huasi, on top of a narrow quartzite dyke, with the Uyuchama River visible below.*

about 20 m upslope from the petroglyph area, occurs a slightly sloping sandstone pavement covered by numerous horizontal polished grinding dishes, each around 50 or 60 cm long. These are better preserved than the petroglyphs on the same type of rock nearby, and are spatially separate from them. In the same area occur numerous artefacts on the surface of the sediment deposit, or have been washed out of the soil by rainwater action. Stone tools and ceramic fragments are found here, but are absent below the petroglyph panels.

The excellent preservation of these polished surfaces renders reliable microerosion analysis possible, particularly as the grain truncation surface usually forms an angle of close to 90º with the emerging side surfaces of each quartz grain (Fig. 4). Care only needs to be taken to reliably distinguish between later micro-chipping and actual micro-wanes. One of the polished dishes was selected randomly for metrical analysis, and an area measuring less than 20 mm^2 was scanned systematically at 80×. A total of 35 micro-wane width measurements were secured from this small area. They are summarised in a histogram (Fig. 5), showing a range of 8–15 µm (mean 10.97 µm). This represents a fairly reliable microerosion value, and if a quartz calibration curve were available for the Mizque valley region, it could be readily translated into a numerical age estimate for the polishing action.

In the absence of a local calibration curve I substituted the Grosio curve from Italy (which refers to the climatically most similar conditions; Bednarik 1997b), and in full appreciation of this qualification calculated the age of the particular polished surface at Inca Huasi at E1028 ± 300 years BP. Relative weathering indices of the nearby geometric petroglyphs suggest that they are between two and three times as old as the polished dishes, and if we extrapolate from the maximum tolerance values of these we can safely assume the petroglyphs to be between 1500 and 4000 years old. However, the age of the random cupules on the quartzite dyke, the oldest rock art at the site, remains impossible to guess, except that they are significantly older again. They are certainly the oldest rock art I have ever seen in Bolivia — indeed, in all of South America. I suspect they are of the final Pleistocene, as the petroglyphs in Cueva Epullán Grande in Argentina appear to be (Crivelli Montero and Fernández, 1996), or perhaps of the early Holocene.

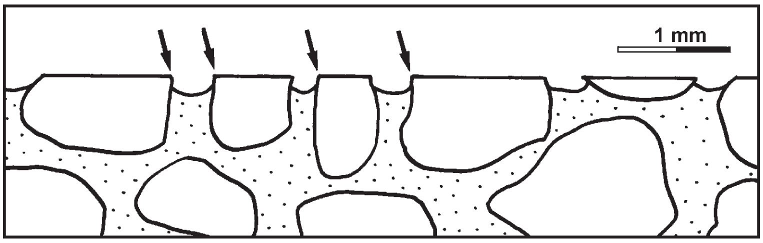

Figure 4. *Magnified section through the polished surface, showing the truncated quartz grains. The arrows indicate the edges created by the grinding action, where the micro-wanes were measured.*

Subsequent to obtaining these analytical results, R. Querejazu L. informed me that there are three distinctive occupation phases archaeologically observable at or near the Inca Huasi site. One relates to a culture rich in ceramic finds and dates from about 1000 years ago, then there is an earlier culture lacking a pottery component, and before that a Paleo-Indian presence. This again appears to correspond to my analytical results. For greater details about the findings at Inca Huasi, see Bednarik (2000, 2001, 2002b).

Toro Muerto

Microerosion data were derived from three more Bolivian petroglyph sites, but not from the rock art itself. An entirely new approach was adopted in 1997 at Toro Muerto. Petroglyphs occur

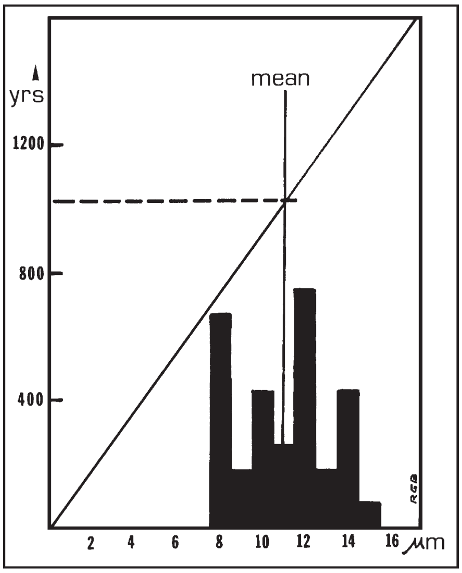

Figure 5. *Microerosion histogram of polished dish at Inca Huasi, with the Grosio calibration curve placed experimentally to obtain a rough age estimate.*

mostly in a sheltered position, where microerosion analysis is ineffective because of the absence of rainwater solution. I decided to instead study the discarded stone tools used to make petroglyphs at this site. After examining each implement found on the rock shelf in front of the cave, I recognised ten tools that had been used in producing rock art, as hammerstones (for details of recognising these, see Bednarik, 1998b). From these I selected the five best specimens, in terms of their specific characteristics and their susceptibility to microerosion study. These were subjected to detailed laboratory examination, which showed that three of them date from about the same time; one is almost twice as old, while the fifth has clearly been used on two different occasions, separated by about 3500 years. Petroglyphs were produced at the site for about 4000 years, and at least three discrete episodes of use can be recognised from the tools alone. This confirms my earlier finding, that the Toro Muerto petroglyphs represent several distinctive phases, and it corresponds closely with an independent estimate of the age of this rock art, by Alan Watchman (pers. comm. 1997), who on the basis of his examination of the accretionary deposit over some petroglyphs at the site estimated that they may be 2000–4000 years old.

Toro Muerto is a small cave in the Mizque valley, near the town of Saipina, central Bolivia. Located under a prominent rock outcrop on the slope of a minor side valley c. 100 m above the river, the cavity formed in a siliceous sandstone facies of variable composition. Its shape is determined by two factors: the presence in the rock of a curved lamina of dense, almost quartzite-like composition (possibly resulting from contact metamorphism), and the gradual process of laminar exfoliation or granular fretting. During recent millennia, at least since mid-Holocene times, the cave walls and ceiling were comparatively stable, except as noted below, which has facilitated the survival of a dense cover of rock art, occupying nearly the entire wall area. There is ample evidence of long-term use and re-use, with art and retouch having been executed both as petroglyphs and pigment applications. Here we focus on the petroglyphs and their age.

The cave of Toro Muerto is only 4.10 m deep, while its distinctively elliptical entrance is 6.15 m wide and 2.60 m high at the dripline. The entrance faces almost due west, the rock floor rises towards north, and the thin floor sediment is limited to the first metre in from the dripline. In front of the entrance, the sparse sedimentary cover slopes down gently for about 5 m to a 4-m-wide rock shelf from which the valley can be surveyed. Immediately to the north of the entrance, a 3-m-wide rock shelf rises steeply, at 42° at its base. The lower part of this slope, just outside the cave's drip-line, bears three arrangements of much corroded, barely perceptible cupules, which were only discovered in the course of this study. One forms a vertical alignment, 76 cm long, of eight fairly evenly spaced cupules, another a horizontal line of five cupules. There is also a group of ten smaller cup marks, between these two sets, which form a vague geometric arrangement. Some further, single cupules may also be present in this vicinity, but the state of preservation and the presence of at least five distinctive lichen species permit no reliable identification. All cupules are similarly weathered, and are indistinguishable from the general rock surface. In size, these cupules range from 20 to 70 mm diameter and from 6 to 18 mm depth.

Inside the cave, a thick cover of black lichen indicates where rainwater flows occasionally down the wall in two locations, and there is a fossil termite track from floor to roof. On the ceiling and around its cornice, numerous remains of insect nests survive, including nests of mud-dauber wasps. These seem to belong to two species as indicated by two morphological types. One is of circular structures which occur in their hundreds, the other of elongate groups of cells. The latter are often heavily mineralised, probably by carbonate and possibly by gypsum, which indicates that the cave has experienced a very moist phase in the past. The insect nests cover very few petroglyphs, but are nevertheless probably suitable for luminescence dating.

Despite the small size of the cave, the rock art panel in it is a total of 8 m long, being mostly about one metre high. Much of it has become exfoliated through the subcutaneous deposition of salts, particularly gypsum. This process may have been assisted by solar radiation, because in the late afternoon much of the back wall is exposed to the sun. The rock art sequence can be related to this evidence as well as to episodes when several accretionary deposits formed, providing a relative chronological framework. All petroglyphs appear to be non-iconic, motif types including two forms of framed cross, wave line, arcs or U-shapes, comb motif, convergent lines motif, figure 8 and rows of cupules. Small aligned cupules may be connected by a groove, or occur at the ends of grooves. Many of the petroglyphs show later retouch (Figs. 6 and 7).

The five hammerstones collected just outside the cave that were subjected to microerosion analysis bear one or two percussion facets each. One of them also features remains of red pigment acquired when it was used to strike the rock wall decorated with ochre pictograms. The tools are all of similar size and weight, their maximum dimensions ranging from 58.2 mm to 64.2 mm (Fig. 8). The micro-wane data represent three distinctive clusters, ranging from about 500 years to 4000 years BP. It needs to be emphasised that the tools cannot be related to any specific petroglyphs, and that these preliminary dates cannot exclude the possibility that some petroglyphs may also have been produced outside that time range. However, the results do confirm the great duration of rock art production in this much-used site, which is also evident from the complex sequence of accretionary deposits, weathering, exfoliation and intervening petroglyph creation. They also furnish this sequence with a minimal time

Figure 6. *Petroglyphs in the cave of Toro Muerto, central Bolivia.*

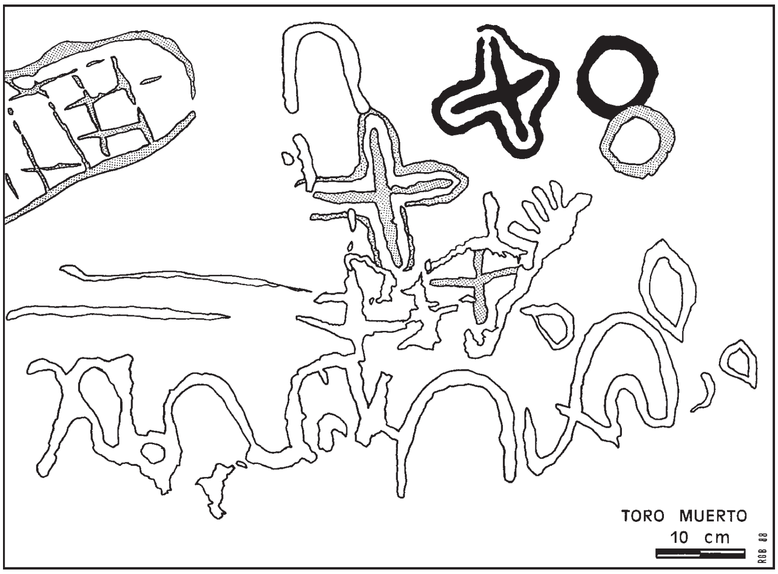

Figure 7. *Selection of petroglyphs in Toro Muerto, showing examples of the extensive superimpositions.*

Figure 8. *The hammerstones from Toro Muerto subjected to microerosion analysis. They were used in the production of petroglyphs at various times between 500 and 4000 years ago.*

depth, suggesting that much if not the entire site's rock art production dates from various times of the second half of the Holocene.

The Kalatrancani-Roca Fortunato complex

Close to the perimeter of the foothills of Mt Tunari, near Cochabamba, occur various petroglyph concentration. The largest currently known is located at Kalatrancani, including the sites of the newly discovered rock art complex of Roca Fortunato (Querejazu Lewis, in press). At the present time, 2008, the complex comprises the sites of Llave Chico, Kalatrancani 1, 2 and 3, Roca Fortunato 1 and three satellite sites of the latter. These sites are under continuing investigation and only the most preliminary details can be provided here. They consist of rock outcrops rising from a metre to a few metres above the sediment, and where the upper surfaces are flat and covered by petroglyphs (mostly cupules, but also other motif types and abraded grooves at some sites), it has been possible to recover hammerstones or, more often, small quartz splinters with impact evidence that were evidently detached during the production of some of these petroglyphs.

At Kalatrancani site 3, seven tiny chips of white quartz were found lodged in cracks among the petroglyphs, and at Kalatrancani 1, a petroglyph-making tool of the same white quartz was discovered. These finds are perfectly suited for microerosion analysis, and this is the first time in the world that such material is used in microerosion analysis. Preliminary results indicate that the chips from Kalatrancani 3 are about 500–600 years old, while the damage incurred by the Kalatrancani 1 tool is slightly older. Precise determinations are still to be made, but in the absence of a calibration curve they will have to be regarded as tentative. More recently, in 2007, a few similar quartz chips were recovered from cracks in the upper surface of Roca Fortunato 1, but these have not as yet been analysed. Results of this research will be reported in due course (Bednarik and Querejazu Lewis, in prep.).

In summary, this ongoing

project has provided the first analytical age estimation results (Table 1) from any South American rock art, all of which have been secured from central Bolivian petroglyphs.

Acknowledgment

Most of my rock art research in Bolivia has been, and continues to be, guided by Professor Roy Querejazu Lewis, and I take this opportunity to express my gratitude to him.

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