Remote Sensing Archaeology:
Searching for Lake Parime from Space

UNIDAD DE ESTUDIOS ARQUEOLOGICOS, INSTITUTO DE ESTUDIOS REGIONALES Y URBANOS, UNIVERSIDAD SIMOM BOLIVAR, CARACAS,VENEZUELA.
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FUNDACION MUSEO DEL MAR, NUEVA ESPARTA, VENEZUELA.

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Abstract

This research evaluates and discusses distinct types of data to propose the possible existence of an extinct lake which was reported by the chronicles and depicted on most South American maps from the end of the 16th century to the mid-19th century. The methodology and results derive from the analysis and combination of historical sources, indigenous oral traditions, geological and archaeological studies, digital elevation models (DEM) as well as aerial, and satellite remote sensing surveys performed by NASA's Shuttle Radar Topography Missions (SRTM), the Landsat Enhanced Thematic Mapper Plus (ETM+) instrument, and the TanDEM-X synthetic aperture radar (SAR) sensors at the German Aerospace Center (DLR). In addition, an assemblage of artifacts discovered within the study area is also assessed and contrasted to the historical and the remote sensing results.

Keywords: Landscape Archaeology, Remote Sensing studies, Lake Parime or Manoa, Digital Elevation Models, Assemblage of Artifacts, Venezuela, South America.

[1] José Miguel Pérez-Gómez
Unidad de Estudios Arqueológicos, Instituto de Estudios Regionales y Urbanos,
Universidad Simón Bolívar. Caracas, Venezuela.
Fundacion Museo del Mar, Nueva Esparta, Venezuela.

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[2] Charles Brewer-Carías
Academia de Ciencias Físicas Matemáticas y Naturales. Caracas Venezuela.
Fundación Explora, Caracas, Venezuela.

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[3] Andrzej T. Antczak
Faculty of Archaeology, Leiden University, Leiden, The Netherlands.
Unidad de Estudios Arqueológicos, Instituto de Estudios Regionales y Urbanos
Universidad Simón Bolívar, Caracas, Venezuela.

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[4] Maria Magdalena Antczak
Faculty of Archaeology, Leiden University, Leiden, The Netherlands.
Unidad de Estudios Arqueológicos, Instituto de Estudios Regionales y Urbanos
Universidad Simón Bolívar, Caracas, Venezuela.

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[5] Giovanni Marchisio
Vice President of Analytics. Planet, San Francisco, CA, USA.

---

[6] Thomas Busche
Microwaves and Radar Institute, German Aerospace Center (DLR)
Wessling, Germany.

---

[7]Alejandro Chumaceiro
Soluciones Integrales Gis, C.A. (SIGIS) Caracas, Venezuela.

[8]Karel Bentata
Caracas, Venezuela.

[9]Sarkis Yammine
Fundación Yammine, Caracas, Venezuela.

[10]Roger Swidorowicz
Fundación Sigma Dental.

[11]Federico Mayoral P.
Caracas, Venezuela.

[12]Charles Brewer-Capriles
Fundación Explora, Caracas, Venezuela.

[13]Ricardo Trevisi
Caracas, Venezuela.

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We would like also to express our gratitude to all the *Soluciones Integrales GIS C.A. (SIGIS)* personnel, for their genuine and kind support to our research. In addition, we would like to express our appreciation and gratitude to all our bush pilots: Enrique Nevett Gimón, Alejandro Chumaceiro, Gustavo Tovar Phelps, Ricardo Trevisi, Karel Bentata and Oscar Noya Alarcón, for flying us into unknown territories. Most special recognition goes to all of our Indian guides, boat captains and helpers in the bush through all this time and since the beginning of our expeditions, without them our work would have been very difficult if not impossible.

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Introduction

No other story has gripped South America's collective imagination to a greater extent than the legend of a huge lake called *Parime* or *Manoa* located in a remote territory between the Orinoco and Amazon River Basins. It has figured in indigenous tales and appeared on most South American maps from the end of the 16^{th} century through the mid-19^{th} century. As soon as the Europeans heard about such a territory, distinct from those already discovered in Mexico and Peru, the news spread swiftly throughout the old continent. It triggered literally hundreds of search expeditions. The first references to the lake appeared in Quito in 1534 in the form of an Amerindian's story of a chief who used to make ablutions of gold material in a lagoon (Ramos-Perez 1973). References gained strength in 1541 through the writings of the chroniclers Pedro Cieza de Leon, Fernandez de Oviedo, and Juan de Castellanos (Ramos-Perez 1973). Surprisingly in 1590, and almost two thousand kilometres away from Quito in the lower Orinoco River, Spanish captain Antonio de Berrío also heard from various indigenous groups that at some distance in the province of Guayana (located beyond both the Orinoco and a mountain range) existed towns situated beside a lake which they called *Manoa* (Domingo de Vera 1593; Ojer 1960; Hemming 1984; Lovera 1991).

The first map of this lake was probably produced by Sir Walter Raleigh, but ironically other maps of the lake based on his own annotations had been published previously (Appendix I). In addition to being one of the most influential men of his time in England (Dilthey 1944; Von Hagen 1974), he was also a prolific writer. His book *The Discovery of the Large Rich and Beautiful Empire of Guiana* not only mentioned the lake—or would do so centuries later, as seen below—but went on to detail that it was 200 leagues (about 1,000 km. or 600 miles) in length and salty (Raleigh 1595). It is obvious that this map was based on Spanish information; perhaps Raleigh had his own indigenous sources as well. Nonetheless, he decided not to incorporate the map in his book possibly because he judged that it revealed highly secret information (Fig. 1). As a result, the map was lost for 273 years until accidentally purchased among a batch of ancient documents by the British Museum in 1849. Hence the map was not known to other South American explorers such as Sir Robert Schomburgk (Nicholl 1995) and Alexander von Humboldt, who could have probed the continent based on Raleigh's observations. In fact, Humboldt´s extensive surveys of the Orinoco River´s basins and lakes led him to conclude that Lake *Manoa* or *Parime* had never existed and deserved a place beside the body of Greek, Indus and Persian myths (Humboldt 1985). Humboldt believed that the tale of the lake was likely inspired by seasonal flooding at the confluence of the Urariquera River tributary streams (Van Heuvel 1844; Humboldt 1985).

The interest in the re-evaluation of the existence of Lake Parime or Manoa was inspired by the results of an anthropological expedition conducted by Napoleon Chagnon and Charles Brewer-Carías in southern Venezuela in the year 1990. In that opportunity a series of artifacts in the context of a Yanomamö indigenous peoples communal house or *shabono* was recovered (Fig. 2). This suggested the presence of a pre-colonial indigenous society in this part of Venezuela. Preliminary research of these artifacts was conducted years later and is described below. However, in order to situate this archaeological site within wider geographical context a remote sensing survey of the study area was performed with the aid of Landsat ETM+ imagery together with a 90m Digital Elevation Model (DEM) from NASA's SRTM. This was done in order to situate this archaeological site within the local and wider geographical context. Once the archaeological site was geo-referenced, preliminary analysis of the DEM image evidenced an extensive lowland area subject to floods and controlled by a mountain ridge, suggesting the basin of an extinct lake. This phenomenon is surprisingly consistent with the one depicted on Raleigh's map (Raleigh 1595). In addition, the geographical location of this potential lake in the

DEM images also coincides with the position of such a lake on most posterior maps of South America from 1599 to 1844. These show an elongated lake between the Orinoco and Amazon

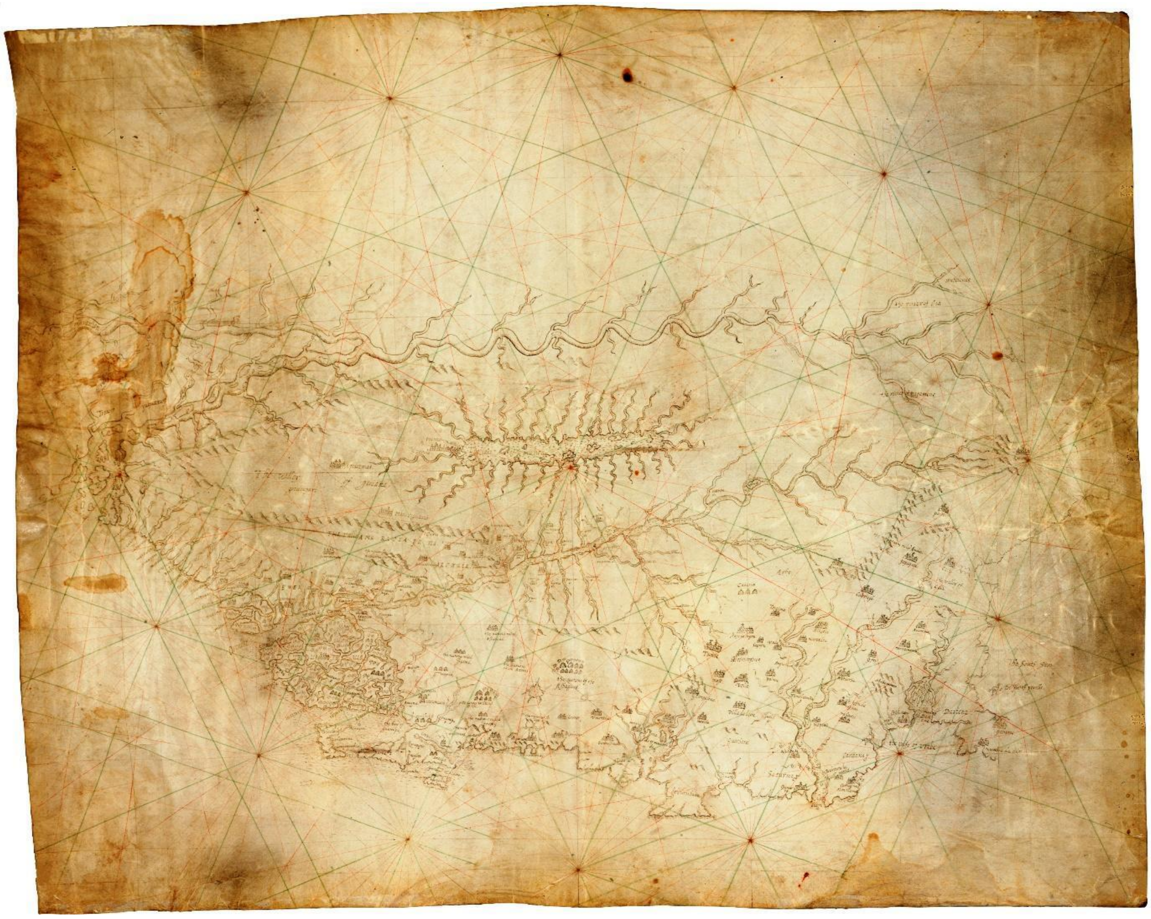


Figure 1. Walter Raleigh's map depicting the lake and the city of *Manoa.* 1868 Add, MS. 17940 A. (Image ©The British Library Board)

Rivers (Raleigh 1595; Hondius 1598; Schomburgk 1845). If there indeed was a lake within the context of the study area where the artifacts were found, the question arises: Why did it dry and where did it drain? Will the digital elevation models contribute to an answer to these questions and account for its existence in the past? Can the indigenous society that produced the discovered artifacts be related to the potential lake? To seek answers to these research questions, several satellite and aerial photographic surveys were performed to augment the initial remote sensing observations with additional data.

Our research has confirmed that although archaeology mostly relies on visual recognition of past remains, most such are hidden from view, like ancient river courses, old lakes or field boundaries. They are buried underground, reduced by environmental processes, or obscured by vegetation. Remote sensing studies can not only reveal these hidden remains but also place them in much larger contexts, showing past social landscapes in all their complexity (Parcak 2009). In 2007, the first DEM observations of the artifacts' geographical context resulted from the SRTM, initially at 90m and then at 30m resolution. These observations enabled us to understand the landscape and detect the lowland area. Seven years later, the development of the Synthetic Aperture Radar (SAR) TanDEM-X missions offering imagery at 12m resolution has initiated a new era of landscape research (Tapete & Cigna 2017). It has contributed greatly to the research discussed in this paper by refining previous observations of the possible drainage area. It has established more accurate flood projection and helped to estimate water volume. The evidence gathered to date suggests the possibility of a fossil water reservoir.

Aims and Data Processing Methods

Distinct types of remote sensors were employed in this research for the analysis and interpretation of the study area. Remote sensing surveys were carried out with the aid of satellite imagery from several types of sensors (Table 1). The data output from these were contrasted and blended through a bundle of distinct software tools including PCI Geomatics and Global Mapper for SAR products, Envi EX for multispectral imagery, and ArcGis for data integration. The ETM+ imagery (~15m) and the SRTM 1 Arc-Second (90~30m) DEM mosaic were acquired using the "Earth Explorer" interface, an extraordinary remote sensing tool developed by the United States Geographical and Geological Survey (USGS). In addition, 12m datasets of the study area from the TanDEM-X missions were granted to this research through the TanDEM-X Science plan (DLR 2010) at the DLR`s Microwave and Radar Institute in Munich, Germany.

Table 1. List of remote sensing data sources used in this study. (Compiled by José Miguel Pérez-Gómez)

Sensor	Acq. Date	Off Nadir Angle	Ave. Target Azimuth	Band Info
SRTM	Feb 12 2004	19º	215º	SIR-C/X-SAR ~90m
SRTM	Jun 19 2003	19º	210º	SIR-C/X-SAR ~30m
7 ETM+	Jan 21 2010	21º	210º	MULT -15m
TanDEM-X	Feb 4 2017	40º	221º	X-Band INSAR ~30m
TanDEM-X	April 7 2016	35º	225º	X-Band INSAR ~12m

For each of these sources, pre-processing algorithms were applied to enhance the quality of the image data, reducing or eliminating various radiometric and geometric errors caused by internal and external conditions (Bruce & Hilbert 2006; Maglione 2016). Processing of the Landsat image was accomplished using the Envi EX tool. It included geometric correction, ortho-correction, correction for noise, conversion to top atmospheric reflectance units, topographic normalization, relative radiometric correction, and atmospheric correction (Comer & Harrower 2013). This resulted in an image of the study area suitable for geologic vegetation and geochemical studies. Radar products from the SRTM and TanDEM-X missions (DLR 2010) came pre-processed. Nevertheless, before analysis of the images, the data was orthorectified, mosaicked and geocoded to the WGS84 coordinate system. Strip map data in a bi-static mode from the TanDEM-X sensor was processed using the "Ortho Engine" tool from PCI. This process resulted in a new elevation model of the study area at 12m pixel resolution and a relative horizontal accuracy of 2m. Chart flow of the remote sensing analysis is presented in Table 2.

Preliminary technological and formal functional analyses have been performed on the ceramic and lithic assemblage collected from the study area in order to assess its possible association with the potential lake basin. Both macroscopic and microscopic aspects of the assemblage were assessed using archaeometric techniques (Fig. 2). Assessment was aided by the use of a digital camera, calibrated callipers, a guide for estimating vessel diameters, and electronic scale for weight measurements. In addition, thin sections were obtained as well as digital reconstructions of the potsherds were made (Appendix II).

Table 2. Remote Sensing Analysis chart flow of the study area.(drawn by José Miguel Pérez-Gómez)

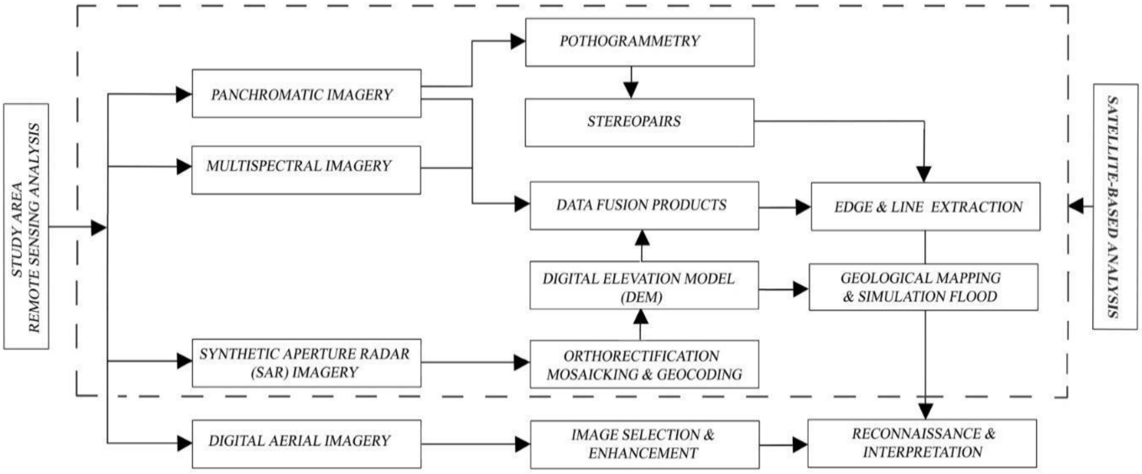


Fig. 2. Images showing potsherds collected in the study area and the reconstruction of some vessels. (Images and profile reconstructions ©Charles Brewer-Carías & José Miguel Pérez-Gómez)

Discussion of the Analyses and their Results

The study was carried out in Amazonas State in southern Venezuela (Fig. 3) within the geographical context of the Guiana Highlands. These Highlands are a great upland characterized by spectacularly eroded *Roraima* sandstones, related sediments, and intrusive elements. These overlay the ancient immutable crystalline Guiana Shield that, together with the larger Brazilian Shield to the south, gives form and permanence to the South American continent (Maguire 1970). The *Roraima* sediments are usually considered pre-Cambrian in

Figure 3. SRTM 30m DEM viewed through Global Mapper showing the two study areas proposed in this research. (Image Shuttle Topographic Mission SRTM ©JPL with additions.)

origin. The sandstone region must have been considerably larger at an earlier time (Gansser 1954). The name "Roraima Series" was introduced by Leonard V. Dalton in 1912 to describe a sequence of sediments with a foundation of granite, gneiss, schist or similar rock (Briceño & Schubert 1992). As within the region of the Yuruary River in Venezuela, these observations cohere with the geological record of British Guiana where the lowest rocks over the whole area form a complex of ancient igneous or highly metamorphosed sedimentary deposits, similar in petrological character to the oldest rocks in other parts of the globe (Dalton 1912).

No fossils or pollen which would permit a more precise dating have been found in these sediments. Accordingly, it has been stated that these sediments are continental and not of marine origin. Long after these sediments were deposited, tectonic movements produced a series of fractures in the mountains into which magmatic material was then injected (Brewer-Carías 1994). Potassium–argon dating (K-Ar) and Rubidium-strontium dating (Rb-Sr) performed on the diabases present across these sandstone mountains place their origin at 1.7 billion years ago (Snelling 1963). These Archaean rocks occur over the entire Venezuelan Guiana Shield region. They constitute hills in some areas but generally form the more or less level platform from which the more notable elevations rise. The older series of rocks consists of acidic material, mainly quartz-porphyrites and felsites which with the surrounding rocks have undergone considerable dynamic or regional metamorphism (Briceño & Schubert 1992). Traversing these, in belts featuring a general N.W. - S.E. strike, are dykes and sills of basic material including basalts and dolerites. Intrusions are found along these dykes and sills, particularly near where they intersect with the older series (Dalton 1912).

Two archaeological sites within a general study area are addressed in this paper. One encompasses the place where the purported lake might have emptied; the other is where the artifacts were located (Fig. 4). The preliminary geological survey of the study area indicated that it is dominated by pre-Cambrian sandstones of the Roraima series (Dalton 1912; Gansser

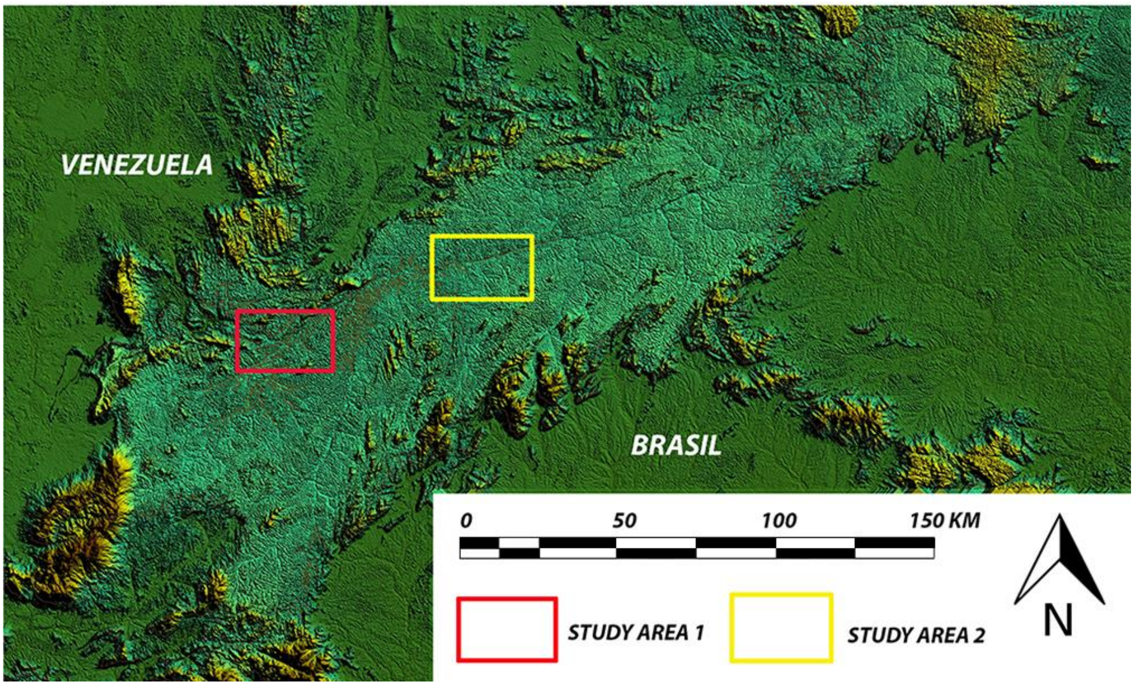


Figure 4. SRTM 30m DEM viewed through Global Mapper showing the two study areas proposed in this research. (Image Shuttle Topographic Mission SRTM ©JPL with additions.)

1954). It is intruded by felsic, volcanic and plutonic rocks. These correspond to the *Cuchivero* province which originated due to a tectonic regime of Andean arch (Talukdar & Colvèe 1974). This arch is characterized by post-collisional, post-trans-Amazonian magmatism which occurred between about 1,930 and 1,790 Ma in the Guiana Shield from Venezuela to Suriname (USGS & CORPOGUAYANA 1993). Such magmatism also occurred across the area being surveyed.

This enormous platform extending nearly 250km in length and 80 km wide, stands at an average altitude of 500m amsl. It is bounded to the north by sandstone ridges known as the *Sierra de Unturan* and delimited to the southwest by the highest of all the *tepuis* (tabletop mountains) in the Guiana Highlands, *The Cerro de Neblina,* which rises to 2.995 m amsl. Nearby climbs *Cerro Avispa* to 1,600m amsl. (Huber 1995), as well as the *Sierra de Unturan averaging heights above 1000m*. These *tepuis* belong to the same Roraima Series. Bordering the south of the platform is *Sierra de Tapirapeco*, a large granitic formation of intrusive rocks with elevations such as *Tamacuari* peak reaching 2,340m amsl. (De Bellard 1996).

Preliminary results have shown that the main study area is characterized by gentle topographic relief. It is controlled by a large horizontal strike-slip fault system running northeast to southwest, which also serves as the bed of the upper Siapa River. The flow of surface water comes from six watersheds at a very low angle. The lowest land surface registered is 478m amsl near the center of the platform. After reviewing the DEM image with the Arc GIS viewer, once again a lowland area at its center was evident. This suggests an extinct water reservoir which can only be seen from space (Fig. 5). When the tributary rivers on top of the mesa were analyzed, the flat surface of the latter became obvious due to the fact that most of the watercourses radiated towards the center, perpendicular to the major river (the upper Siapa) with almost no flow inclination. This in turn suggests that the whole mesa area is quite shallow, as shown in the raw SRTM image (Fig. 6).

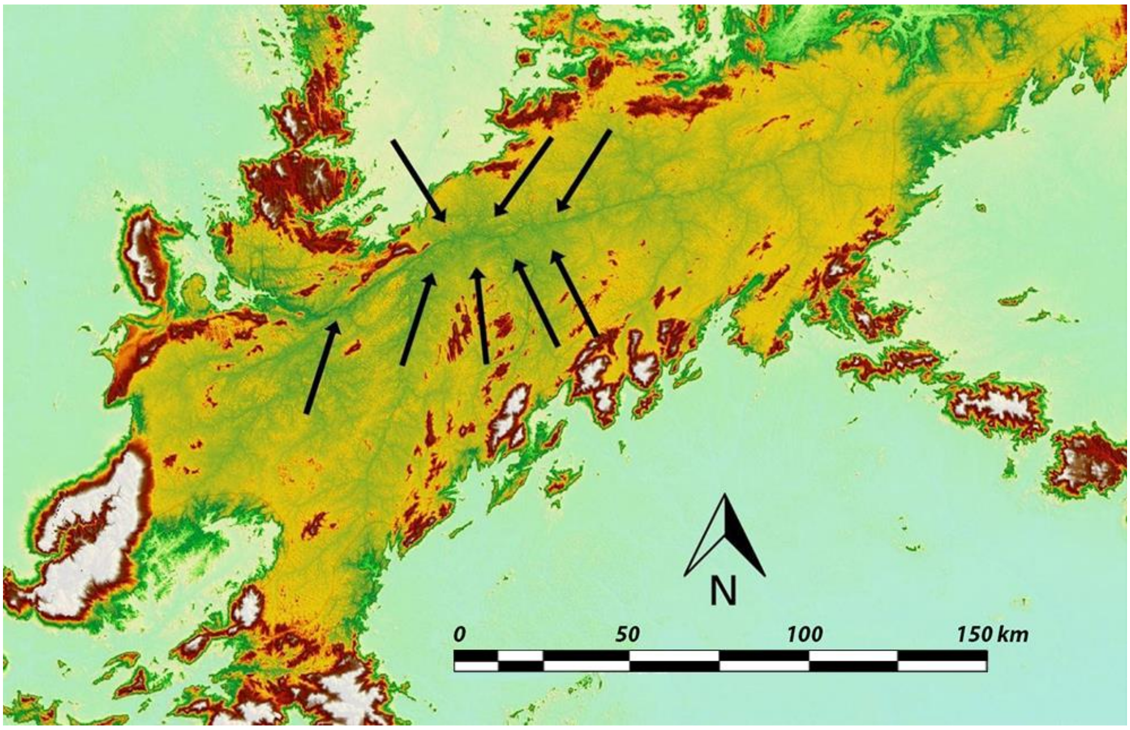


Figure.5. SRTM 30m DEM image viewed with ArcGIS showing a lowland area proposed in this research as a possible lake basin. (Image Shuttle Topographic Mission SRTM ©JPL with additions.)

Interestingly, tributary rivers are similar in their arrangement to those represented On Walter Raleigh's map (Fig. 7). It is obvious that at present there is no lake, not to mention one located between the basins of the Amazon and Orinoco Rivers with the dimensions given in the ancient maps. Nor do modern satellite images reveal anything similar elsewhere in the general region. Nevertheless, proceeding with our preliminary results—which demonstrate the firm possibility that a lake consonant with the early explorers´ reports did in fact exist—why would it have dried out? Could it prove feasible to find the place where the putative lake emptied through analysis of the DEM data?

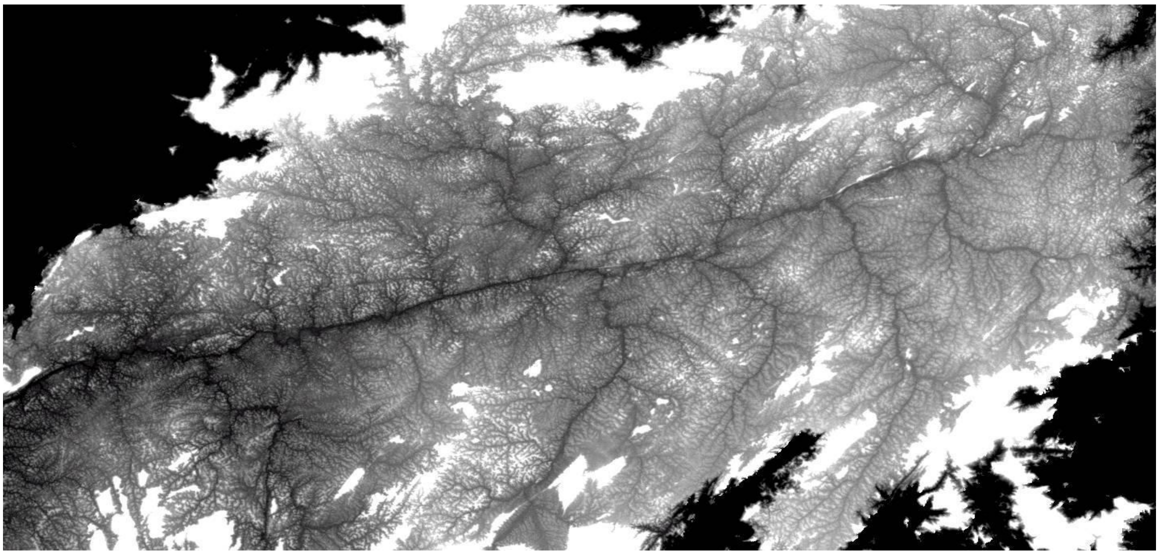


Figure. 6. 30m raw SRTM image showing how tributary rivers radiate towards the center, quite similar to those represented near the lake depicted by Sir Walter Raleigh (Image Shuttle Topographic Mission SRTM ©JPL with additions).

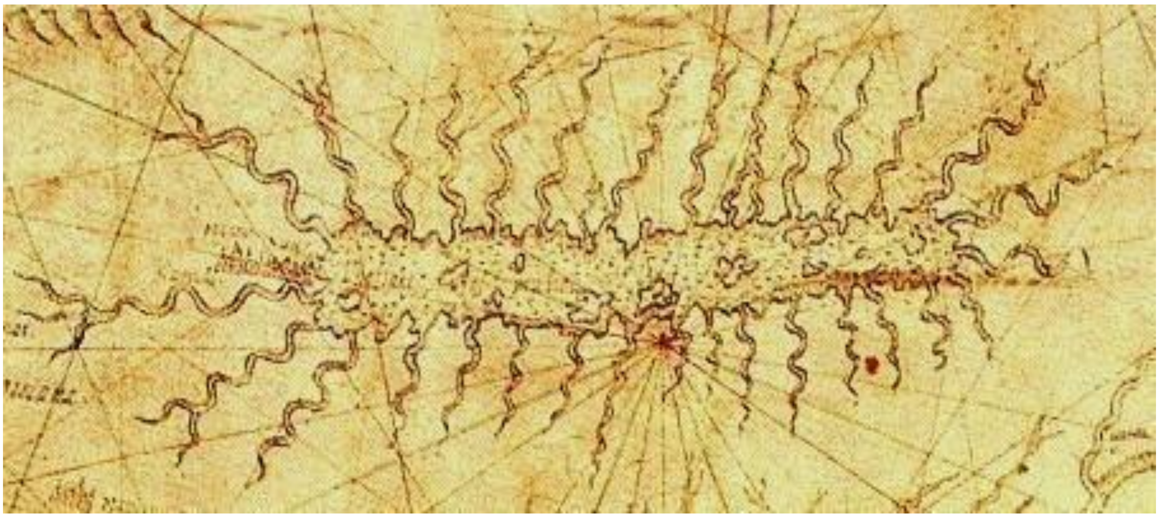


Figure.7. Detail from Sir Walter Raleigh's main chart showing Lake Manoa or Parima. (Image ©The British Museum.)

A more detailed study of these DEM images shows a small mountain ridge intersected by the Siapa river as it exits the platform. Based on geological observations, it is quite possible that this ridge was continuous in the past (Fig. 8). Our research proposes this particular place in Study Area 1 (Fig. 4) as the point at which the putative lake likely emptied. Although we have not visited this area to perform geological sampling, we speculate that this ridge—as part of the Sierra de Unturan mountain range—could have consisted of erodible sandstone, enabling the escape of the water at a given moment. As part of solving problems in water resources engineering, GIS, interweaving the insights of cognitive geography, offers spatial representations of complex hydrologic and hydraulic systems (ESRI 2009). GIS provides the capacity to incorporate related spatial data into traditional water resources databases in order to offer a more comprehensive view of the target region.

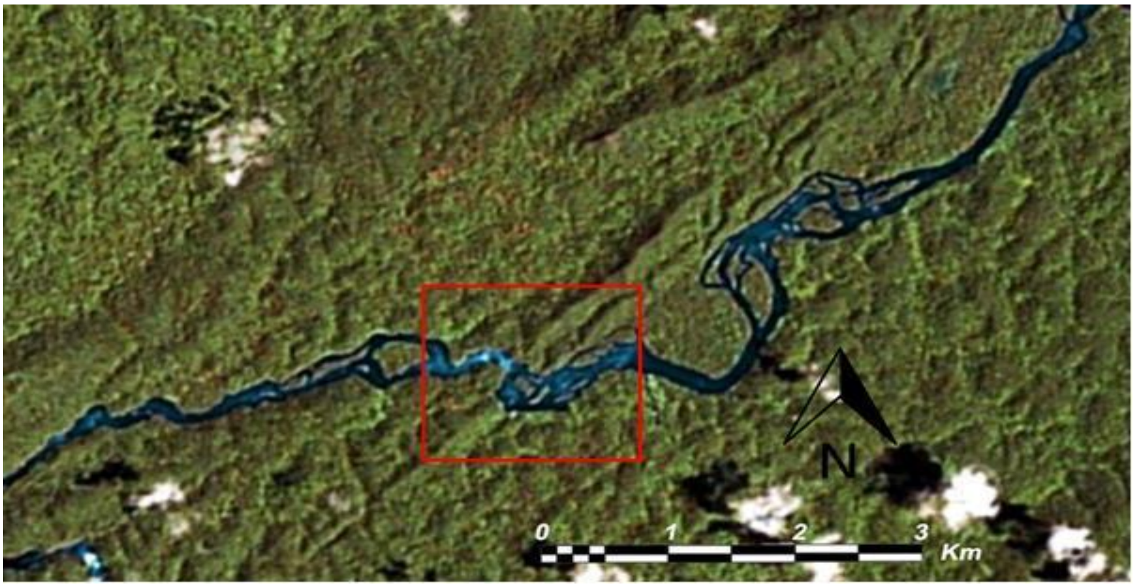
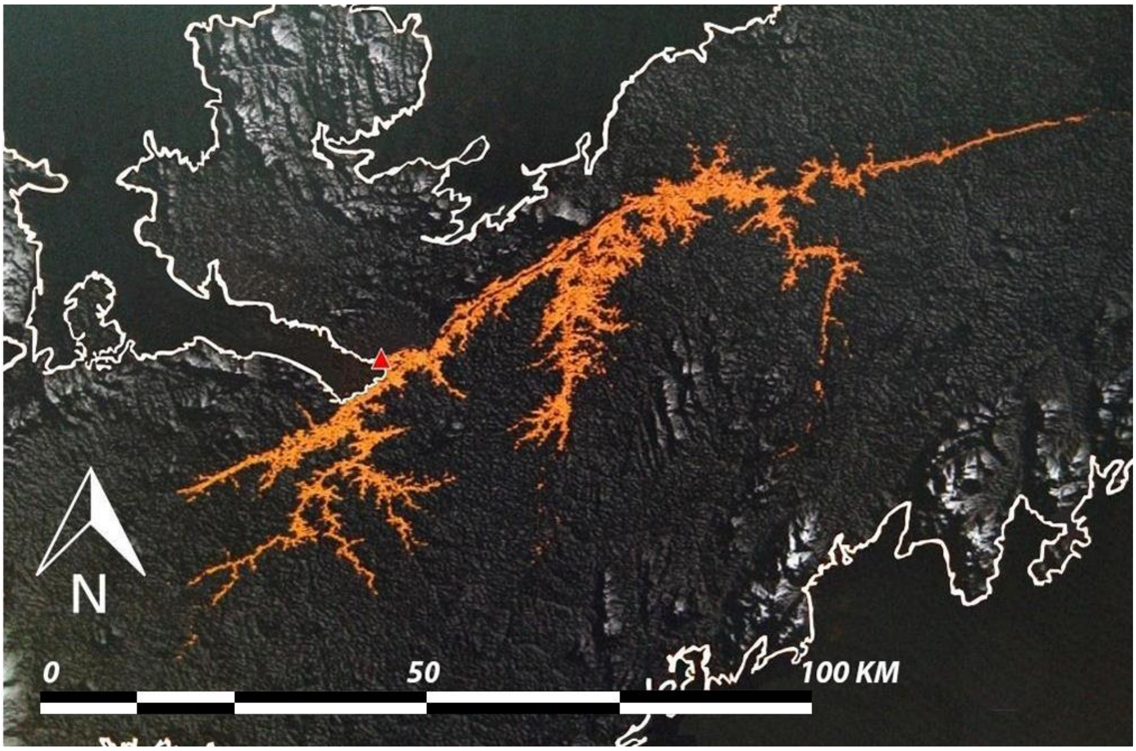


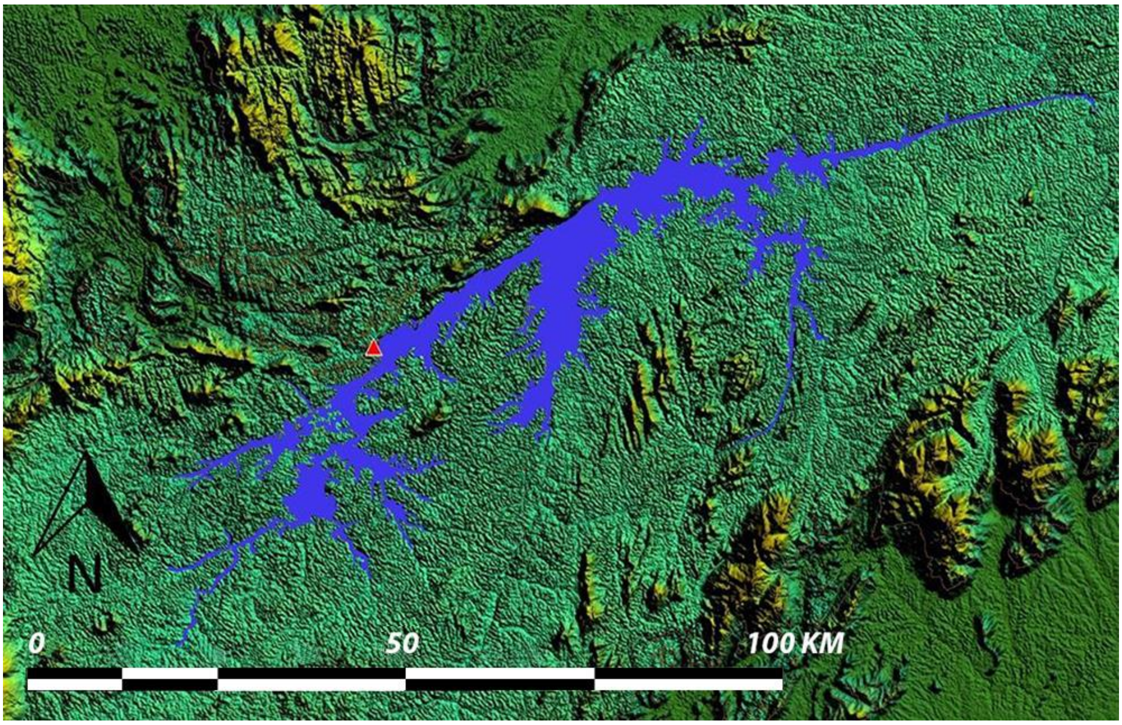
Fig. 8. Landsat ETM+ image showing a small ridge intersected by a stream within the red outlined square. The light blue and white colour in the center of the image shows rapid waters, suggesting differences in the water head. (Image Landsat ©USGS, with additions.)

Of specific interest to decision-makers is the GIS ability to visually display information. This facilitates the interpretation of water resource model inputs and outputs, which in turn enables users to take a more dynamic approach to data input, modification, scenario development, and evaluation (Martin et al. 2005). As a result—and to test the assumption of a possible lake behind this point—a benchmark was projected at 517m amsl by utilizing two elevations (selected from the 90m resolution SRTM image) located at both extremes of the eroded ridge formation: one at 537m and the other at 534m (Fig. 9). This permitted the projection of the results of water inflow behind the same which produced the shape and dimensions that this lake could have had (Figs. 10-11).

Fig. 9. 3D Landsat ETM+ image showing the ridge's elevations of 537 and 534m amsl taken as references for GIS digital lake reconstruction. (Image Landsat ©USGS, with additions.).



Figures 10-11. SRTM 90m DEM images evidencing flood projection at the 517 benchmark level using the Global Mapper tool in 2007. The red triangle indicates the place where the water might have escaped. (flood projection & Images © José Miguel Pérez-Gómez/ SRTM ©JPL)



The study of stream ecosystems has benefited tremendously from use of the landscape perspective (Hynes 1975; Vannote et al. 1980; Fisher et al. 2001). In contrast, only recently have lakes been viewed along a spatial gradient, interconnected through groundwater or surface water pathways or both (Kratz et al. 1997; Riera et al. 2000; Quinlan et al. 2003). By identifying and assessing the importance of spatial structures across lakes, these studies have found that variability of some lake features follows a pattern consistent with the position of the lake within the landscape (Martin & Sorano 2006). In our case, the lake position coincides with the fault system, evidencing a lake controlled by a ridge mountain. This is similar to rift valleys created by tectonic activity. Nonetheless, in 2007 the 90m resolution images were not good enough to propose the possibility of a lake and a drainage area within Study Area 1. This fact obliged us to wait several years more to access better resolution data.

Although the capability of the Synthetic Aperture Radar for archaeological purposes has not yet been fully exploited (Jian et al. 2017), the use of multifrequency, multisensor, multitemporal, and quad-polarization SAR data can provide powerful information to archaeological investigations (Clark et al. 1998; Lasaponara & Masini 2015; Chen et al. 2015). Due to the generous TanDEM-X Science plan offered by the DLR's Microwave and Radar Institute in Munich, we were granted a mosaic image of the study area at 12m resolution in 2017 (DLR-HR 2010). This was processed using PCI Geomatics and the ArcGIS 10.3 software (Fig. 12). Using these tools' interface modules, we were able to delineate the watershed boundaries, flow directions, flow accumulation, and the slope of each cell. As a result, we were able to project a new flood with better resolution to test our previous observations. The new DEM studies not only gave us a better understanding of the dam area; they also confirmed that the only thing required to block the current water flow, in order to recreate a water reservoir, is a hypothetical small dam of less than 30m in length (Fig. 9).

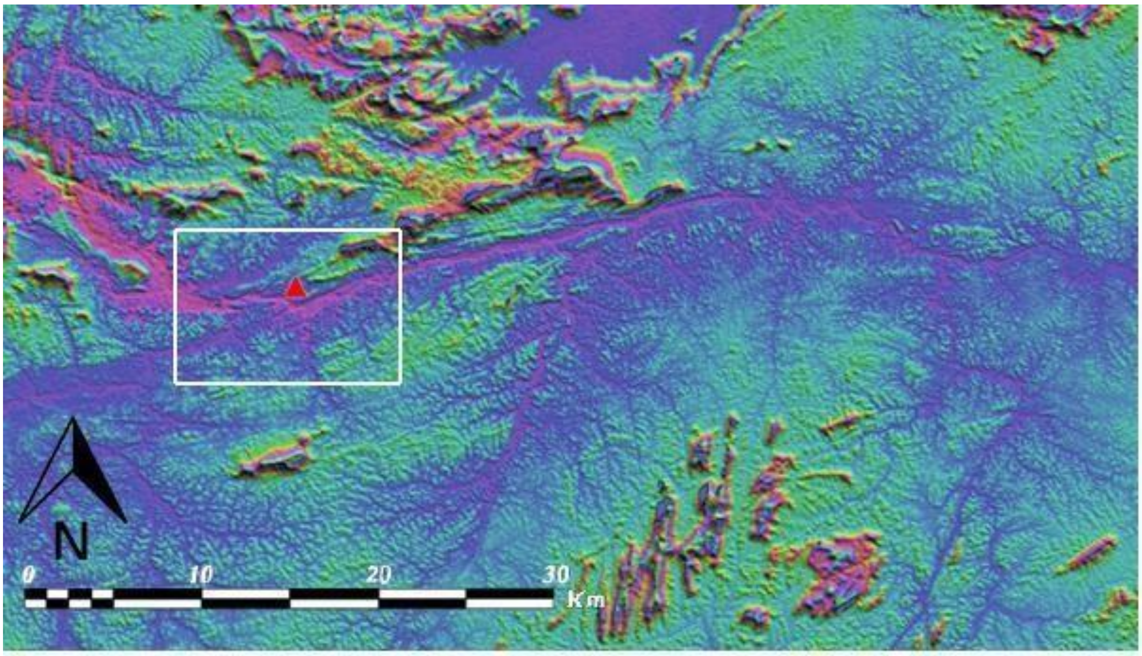


Fig. 12. TanDEM-X image at 12m spatial resolution outlining Study Area 1. Red triangle indicates the dam area where the lake probably emptied as well as the low area (Image TanDEM-X ©DLR, with additions).

The history of a lake may encompass a timespan of few days or even a geological era. A lake may cease to physically exist through infilling with sediments and other materials. Lake basins may also dry by means of drought or changes in the drainage pattern which result in depletion of water inflows or enhancement of outflows. In addition, geologic processes involving the uplift and subsequent erosion of mountains can also cause their disappearance (Rafferty 2011). In most cases, past lake levels are recognized through lacustrine paleoshorelines or terraces. Diatom remains have been used to provide quantitative records of past hydrochemical variations (Roux et al. 1991; Mourguiart & Carbonel 1994). The detailed study of the DEM image at the dam area has shown some possible deposition patterns which are also evidenced in the Landsat image as an inner river delta (Fig. 13).

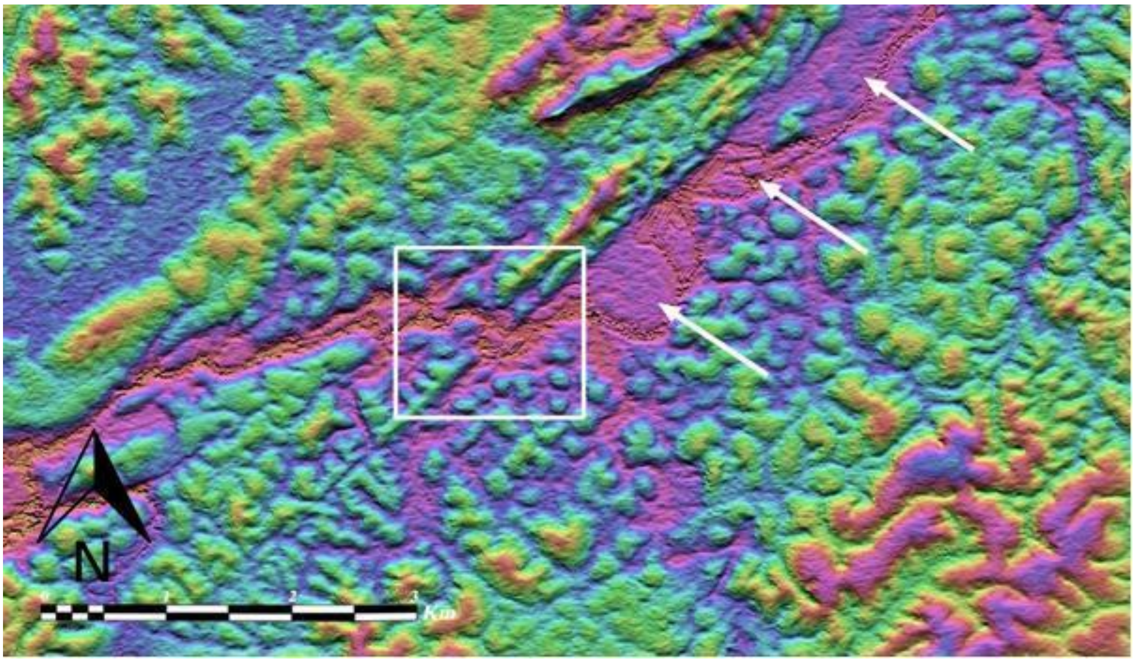


Fig. 13. Detailed view (white square) of a previous TanDEM-X image showing the place where the conjectured lake could have emptied. White arrows indicate potential sediment deposits. (Image TanDEM-X ©DLR, with additions.)

The sediments in question, however, could have been left behind by a lake. Hence core samples to detect diatoms or other lacustrine-associated microorganisms or molluscs are needed from this site to confirm such an assumption. It is interesting to note that a scientific expedition working in the study area in the mid-1990s collected two species of mollusc of the Hyriidae family one of which requires silt-type bottoms (Royero 1996, Martinez et al. 2004) like those found lying on lacustrine sediments (Fig. 14). Naturally other lake studies must be performed with reference to the fields of sedimentology, geochemistry, magnetic susceptibility, and palynology. Two-dimensional perspective seismic data (Abbott et al. 2000) is also needed to strengthen our hypothesis. After considering some of the preliminary results regarding the possible rupture point, other questions arise. For example, what caused the disappearance of the lake? Was the ridge affected by erosion possibly due to abnormal pluviosity with a resulting increase in lake volume pressure over this area? Or was it damaged by a geologic process such as an earthquake?

Fig. 14. Freshwater shells (*Diplodon granossus*) associated with silt bottoms similar to those collected at the study area. (Image © Association Française De Conchyliologie, with additions)

After careful analysis and consideration of the geologic data provided by the DEM models, it becomes evident that this large horizontal strike-slip fault system is also intersected by smaller ones (Fig. 15). Thus, it is possible that the area is prone to seismic activity. The thesis of an earthquake breaking the purported dam therefore becomes highly probable. As a matter of fact, in 1690 Jesuit priest Samuel Fritz reported a large earthquake which shook indigenous constructions as far as one thousand kilometers away (Fritz 2016).

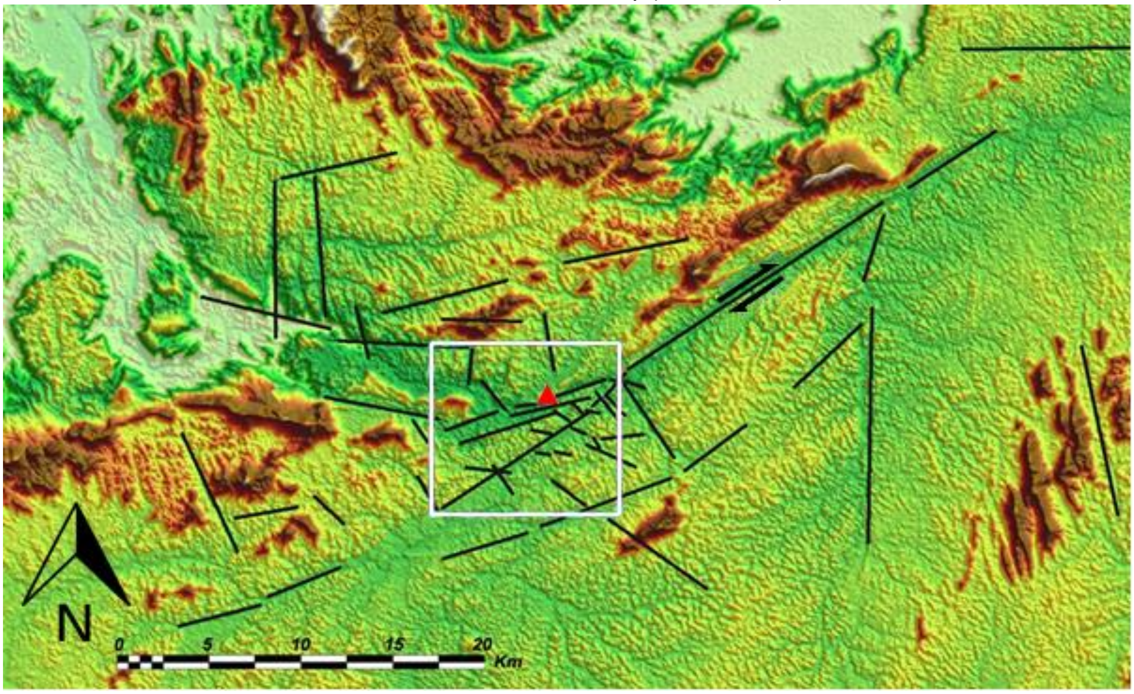


Fig 15. TanDEM-X image at 12m spatial resolution showing fault lines at Study Area 1. The red triangle indicates the low area along with the dam vicinity where the lake presumably emptied. (Image TanDEM-X ©DLR, with additions.)

A calculation of the seismic parameters showed an estimated magnitude of 7, a maximum intensity of IX MM, and a felt area of about 2 million km2 (Veloso 2014). This area includes our study area. Nonetheless, this falls short of establishing that the lake emptied in 1690. It does however demonstrate the propensity of the area to these events, giving rise to the possibility that a previously unrecorded event emptied the lake hundreds of years before the arrival of the first conquerors to the continent. Those figures could have assumed its existence through indigenous oral information transmitted from generation to generation. It is interesting to mention as well that currently, distinct indigenous groups in this same area describe a great flood event in their mythologies (Civrieux 1970; Wilbert 1964; Zerries 1954). Such an event could well have related to the destruction of the aforementioned conjectured dam.

In order to refine the initial observations and test them with a contrasting interpretation, a new hypothetical basin was created using a 12m spatial resolution image from TanDEM-X sensors (Fig. 16). This was projected over the DEM and the Landsat ETM+ images (Fig. 17). The next step was to estimate the water volume through a digital terrain model by using the Triangulated Irregular Network (TIN). A TIN is a representation of a surface derived from irregularly spaced sample points and break line features. It is produced by building a tessellation of triangular polygons from the mass points. The latter are carefully selected to accurately model the terrain surface (Bhargava et al. 2013) and can be derived from their height values. Also, visual 3D animations of the projected flood were generated by using

"ArcScene" in order to understand data patterns over time. These used a benchmark between 450m and 517m amsl (Fig. 18). As a result of this study, the flooding computations for the area resulted in an average of 6.2 billion cubic meters of water, expanding over 400.5 km² with a maximum depth of 70m near the hypothetical closing point.

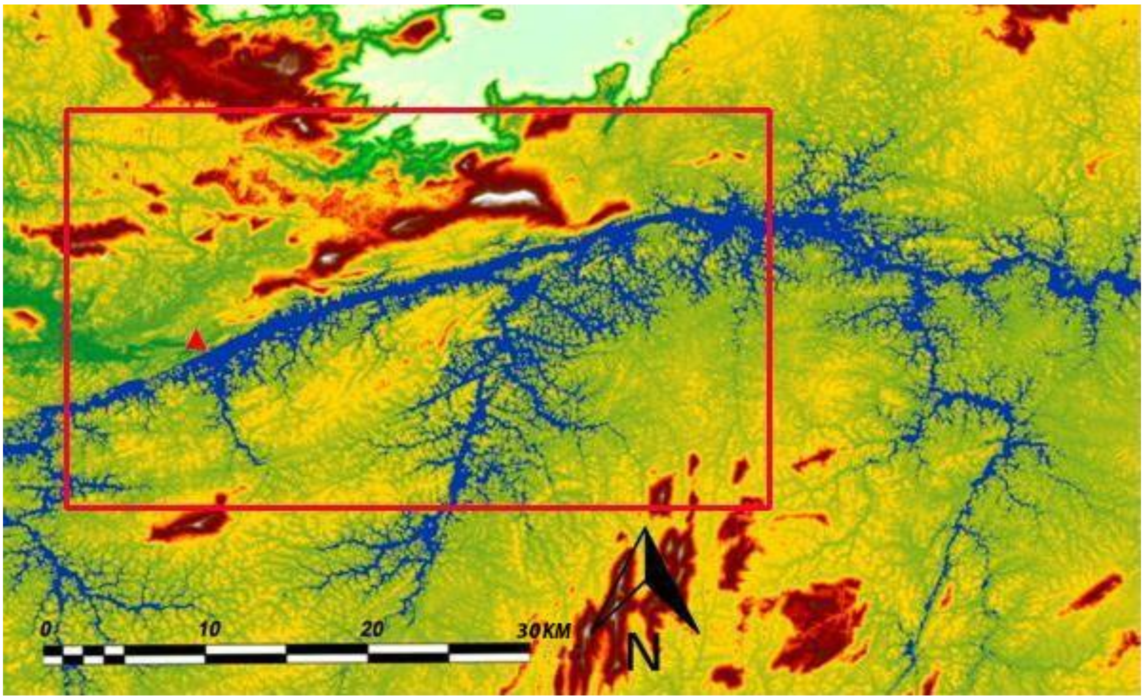


Fig. 16. TanDEM-X image at 12m spatial resolution showing flood projection at 517m amsl. Red triangle shows draining point. Red box outline shows the same flood projection on next landsat ETM+ image. (Image© José Miguel Pérez-Gómez/ TanDEM-X ©DLR)

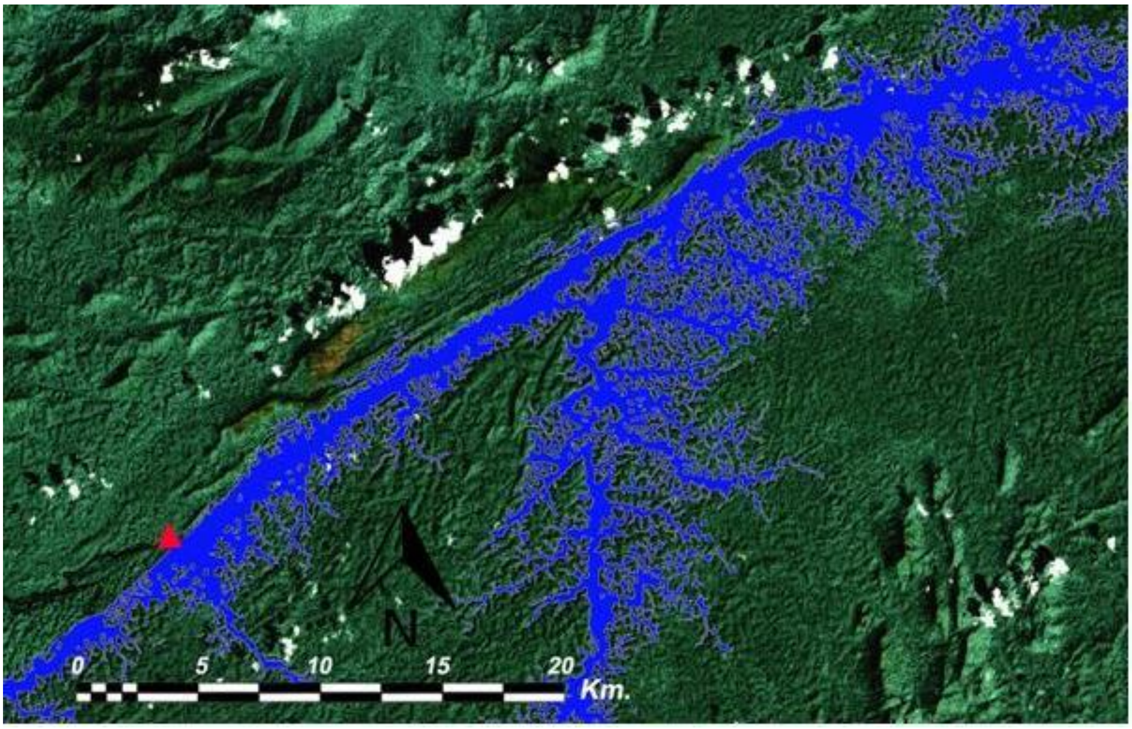


Fig. 17. Flood projection over a Landsat ETM+ image showing a segment of the basin to appreciate its dimensions at 15m spatial resolution. The red point indicates the place of the hypothetical closing area where a benchmark of 517m AMSL was estimated, also depicted in Fig. 12 with a white square. (Image Landsat ©USGS, with additions).

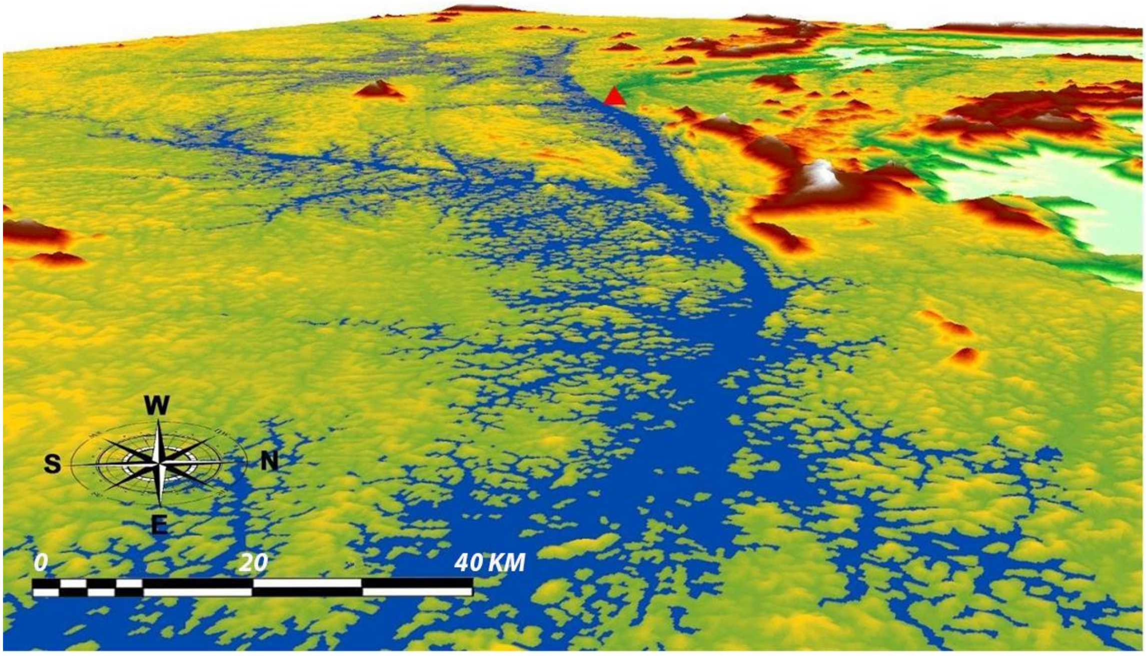


Fig. 18. 3D TanDEM-X image at 12m spatial resolution showing flood projection at 517m amsl. Red triangle indicates the proposed drainage area. (Image© José Miguel Pérez-Gómez/ TanDEM-X ©DLR)

The results of this investigation are extraordinary: it would require only rudimentary equipment to build an adequate small dam in this place. Just 30 meters' wide worth of material would refill the conjectured lake (Figs. 19-20). Based on a GIS flood projection, the proposed former lake basin featured an approximate length of 40 km, a width of a maximum circa 8 km, and an average width across the entire length of about 2km. This suggests a lake much longer than wide: in fact, an elongated rift lake markedly like Raleigh's.

Figures 19-20. Aerial images showing the place of the proposed dam rupture and a digital reconstruction of the lake and the dam. Currently, blocking only 30 meters of flowing water would fill the lake in its entirety. (Images and digital lake reconstruction © José Miguel Pérez-Gómez & Charles Brewer-Carias)

No dating has yet been performed on the archaeological artifacts recovered in the study area. However Initial observations indicate they do not correspond to the Yanomamö indigenous group currently inhabiting the locale. Rather, they are likely of pre-Colonial origin. Yanomamö do not adorn their ceramic pots. They produce only a poorly fired crude clay vessel using the "coil" building technique (Chagnon 1992; Chagnon 2006) known as *hapoka* (Mattei-Müller & Serowë 2007). The temper inclusions observed in most of the potsherds studied (Appendix II) indicate the presence of siliceous "*spicules*" or *cauixi*, showing similarity to pottery tempers found in adjacent cultural regions of Amazonia and Orinoquia. (Antczak et al. 2017; Natalio et al. 2015).

Preliminary study of the archaeological context of these materials shows that they were relatively abundant and buried at a depth of over a half-meter. This could signal a garbage-dumping area or a cultivated expanse enriched by organic matter and charcoal as well as pottery shards to create fertile dark earths. Amazonian Dark Earths (ADE), commonly known as *terra preta*, are characteristic of archaeological sites throughout the Amazon Basin and constitute a legacy of indigenous settlements in the later pre-European period 2000-500 BP (Fraser 2010; Heckenberger and Neves 2009, Neves et al. 2003). The presence of some non-ceramic components in the assemblage, especially the quartz fragments might also suggest an older occupation (Barse 1995), nonetheless recent excavations at the Culebra site indicates that the dating of lithic assemblages can also be contemporary to known ceramic deposits, as can be evidenced at this Orinoco site (Riris et al. 2018).

The *Atures I* component of this occupation is typified by flake scrapers, flake cores, and debitage of local quartz and quartzite. The *Atures II* component consists of flake scrapers and debitage similar to those of *Atures I*, but it also includes tangled projectile points made of chert possibly originating in the interior of the Guiana Shield, similar to the projectile points of Canaima Complex (Antczak et al 2018; Cruxent 1972; Cruxent and Rouse 1963; Gassón 2002). Other artifacts observed in the recovered assemblage, such as elaborated greenstone beads, evidence highly skilled craftsmanship and could have participated in a macro-regional green stone indigenous exchange system (Boomert 1987). Although the assemblage was located in a Yanomamö shabono, initial observations at the location suggest that the archaeological site could be more extensive due to the fact that potsherds were encountered in the surroundings of the shabono as well. We are confident that further interdisciplinary research, accompanied by archaeological surveys and systematic excavations in this area can provide new insights into the timeframe and nature of macro-regional entanglements of this site's occupants and their socio-natural interrelation with past and present landscapes.

Summary and Conclusion

This research uses remote sensing data and software as a primary tool in order to investigate the possible presence of an extinct lake within a particular river drainage system in present-day south-eastern Venezuela. In addition, it critically addresses the documentary sources, archaeology, and oral tradition of the northern part of South American continent in reference to the presence of a huge lake called *Parime* or *Manoa*. This lake, depicted on several manuscript maps beginning in the 16th century, was positioned between the Orinoco and Amazon River Basins. In this paper we indicated the spot at which the supposed lake could have emptied and discussed its possible relation with place where the assemblage of indigenous artifacts was discovered in 1990. Analysis from space with digital elevation models (DEMs) evidenced not only the presence of a relatively lower area where the lake might have existed, but also the point where the purported lake likely drained. In addition, it has been determined that the shape and position of the conjectured lake in the landscape (E-W), generated by GIS flood models, coincides with most historical sources and ancient manuscript maps. We therefore suggest, pending further investigation, that this particular location in the present-day Venezuelan geography could well be where storied Lake Parime, aka Lake Manoa, indeed existed.

The extinction of a lake is a well-known and much-studied phenomenon which can take place even on a single day. The DEMs not only helped establish where this proposed lake could have drained. They also confirmed the presence of large geologic faults within the same geographical context. Because these faults could account for past seismic events in general, it is quite possible to assume that an occurrence somewhere on the spectrum from a tremor to a large earthquake—an example of the latter was reported in the region in 1690—was what emptied the presumed lake. We consequently speculate that the lake was already dry by the arrival of the first European conquerors who likely learned of the place from the area's indigenous oral traditions. Further limnological and other studies related to the purported lake's botany and zoology are indicated to ascertain the presence, or lack thereof, of lacustrine sediments and lake-bottom-related organisms.

Preliminary results from study of the recovered archaeological artifacts indicate their dispersal over an area of more than 150m² and the depth of a cultural strata between 5 and 50cm. Reconstructions of the potsherds attest for the presence of distinct types of vessels used to cook, serve, store and transport dry food and liquids. Although as yet undated, the possibility exists these artifacts are pre-colonial basing on their technique of manufacture including surface finish, firing, and clay temper which evoke pottery vessels crafted by pre-colonial indigenous societies in Amazonia and Orinoquia. Among non-ceramic artifacts figure greenstone ornaments and quartz fragments. The latter could suggest even older occupation of the site or, conversely, may indicate long-distance bartering and local stone tool production resulting from quarrying activities within the proximate area. To date, it is not clear whether the deposition of these artifacts' points to Amazonian Dark Earths (i.e. fertilized agricultural areas) or if they are refuse disposal sites (middens). More archaeological studies are needed to be done in the region in order to shed light on these questions.

Regarding a possible relationship between the artifact assemblage and the purported lake, validated evidence to date is insufficient and inconclusive. Nonetheless, the preliminary research discussed in this paper is a firm first step towards additional surveys and data collection in situ at both study areas. It is evident, for instance, that the artifacts signify an important archaeological site whose further study will contribute to the better understanding of past indigenous societies in this part of Amazonia. At the same time the remote sensing results are not only sufficiently robust to account for an extinct lake basin—which would constitute a major archaeological discovery in itself, but also key to revealing how remote sensing combined with documentary and archaeological data, as well as geology and oral tradition can shed new light on one of the most controversial debates of the past of the South American Continent. Through opening the door to further environmental studies and socio-natural landscape interpretations, aided in the use of cutting-edge technologies such as digital elevation modelling, we envisage further important contributions to rethinking past Amazonian societies and their possible relationship with actual and now-extinct geographical features in South America.

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Appendix I

The Mapping of Lake Parime.

As a result of the publication of Walter Raleigh's book "The Discovery of the Large Rich and Beautiful Empire of Guiana" in 1596, various maps depicting a strange lake appeared throughout the Europe of the 16th and 17th centuries. One of the first was produced by Jodocus Hondius in his "*Nieuwe Caerte van het Wonderbaer ende Goudrycke Landt Guiana"* (Godfroy 2015) which was published in 1596. It was undoubtedly based on information Raleigh gathered both from Spaniards and his interviews with indigenous peoples during his journeys up the Orinoco River. This map shows an elongated lake south of the Orinoco with a settlement called *Manoa* on the northern shore. Hondius's map was afterwards copied by Theodore de Bry and published in his popular Grands Voyages in 1599 (Cutter 1869). When Hondius published a completely revised edition of Mercator's Atlas in 1606, it included a map of South America featuring Lake Parime with the better part of it lying south of the equator (Schwartz & Ehrenberg 1980).

Cartography during the Age of Discovery (the 15th through the 18th centuries) was subjected to a process of concealment in order to prevent key information from reaching an enemy's hands (Corpoguayana 2000). Therefore, it's clear that reviewing maps from this period requires particular care. Despite the lack of scientific evidence for a Lake Parime or Manoa (which is also associated with the myth of El Dorado and called in another time "*Enim* or *The Great Paytiti Empire"* (Humboldt 1985), the body of water still appeared on a few maps for centuries; even into the first quarter of the 19th century as evidenced by James Wild's map of 1829. The legend of a Lake Parime persisted until disproved by Alexander von Humboldt's expedition through Latin America during the years 1799-1804. Humboldt's extensive survey of the Guyana River basins and lakes led him to conclude that Lake Parime did not exist, deserving instead a place among Greek, Indus and Persian myths (Humboldt 1985). Humboldt concluded that the story of the lake was likely inspired by the seasonal flooding at the confluence of the Uraiquera river tributary streams (Van Heuvel 1844).

Walter Raleigh's map

It is believed that Sir Walter Raleigh drew a map (Fig. 21) based on information he gathered from letters sent by Antonio de Berrio to King Philip II of Spain in 1594. These letters had been captured by George Popham, a captain under Raleigh's command (Harlow 1928; Von Hagen 1974; Hemming 1984). That Raleigh himself drew the map is suggested by the handwriting on the document. In particular, the letters in "The Valley of Guiana" are formed the same way as those in Raleigh's poem "The Ocean's Love to Cynthia". Therefore, it is concluded that at least the place names on the map are most certainly in Raleigh's own hand (Nicholl 1995). The map, which Raleigh decided not to include in his book titled "The Discovery" because he'd come to consider it highly sensitive, was lost for 273 years until accidentally purchased among a batch of ancient documents by the British Museum of London in 1849. Consequently, it was not known to the explorer Sir Robert Schomburgk at the outset of his large expeditions. The map was catalogued under the code "Add, MS. 17940" in 1868.

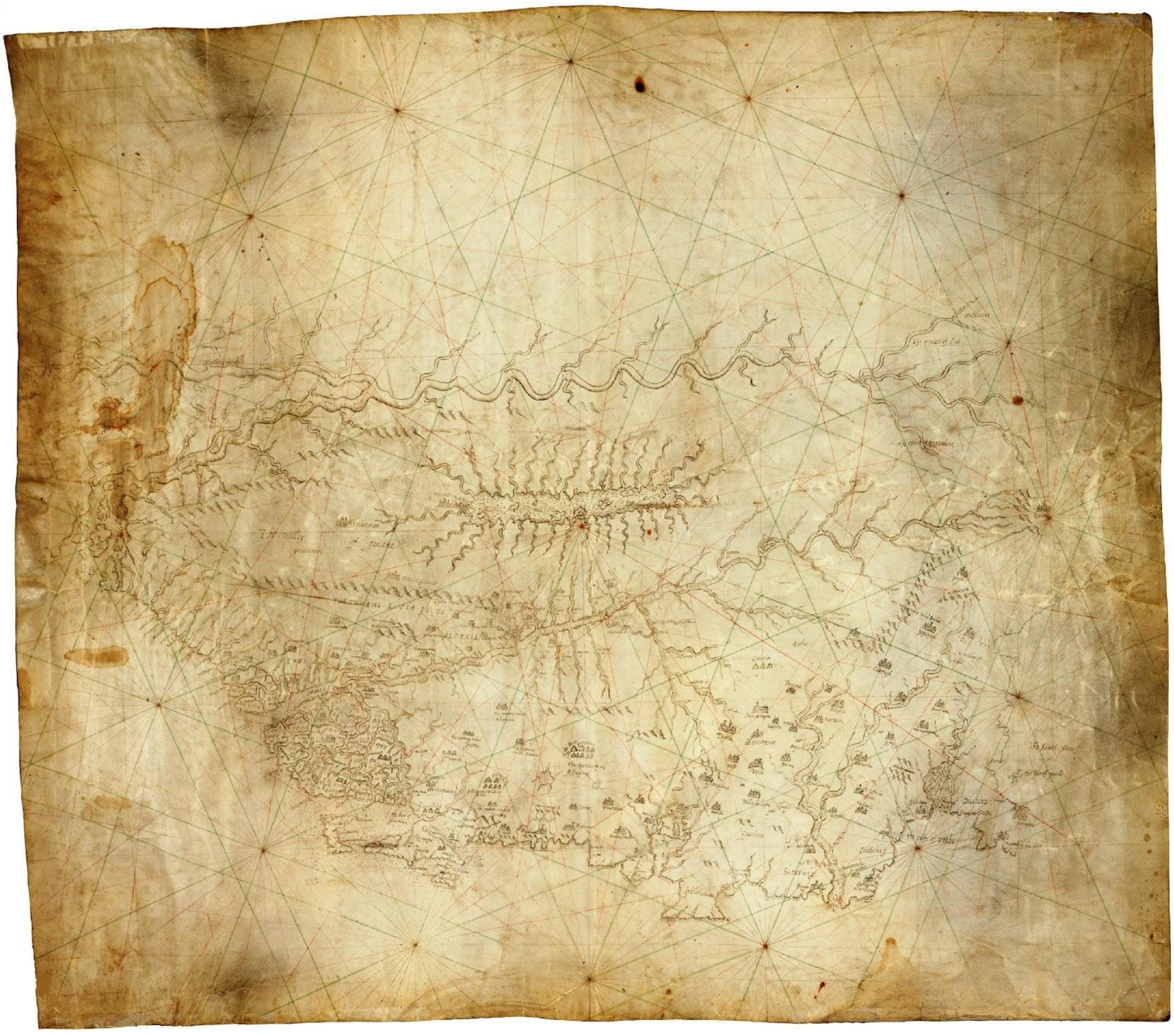


Fig. 21. Walther Raleigh's map depicting Lake Parime, coded Add, MS. 17940. (Image ©The British Library Board.)

The map is remarkably legible. The ink is grayish but still clear; the lines of latitude and longitude are drawn in green and red ink respectively. The orientation is to the south (perhaps due to the map's "secret condition") with the result it must be turned upside down to make conventional geographic sense. The map is purely geographic and in fact a quite accurate representation of the eastern Caribbean coast, the Orinoco estuary and the immediate surroundings of the lower Orinoco (Nicholl 1995). It is interesting to emphasize that, as previously noted, another explorer, Sir Robert Shomburgk, who undertook an investigation and geographical exploration in Guyana in 1838 and who mainly relied on Raleigh's book "The Discovery," ironically enough never saw this map (Nicholl 1995). However, that fact did not prevent him from being the first European to see Roraima (2,810m amsl), the fabulous "Crystal Mountain" (Raleigh 1595, Ramos-Pérez 1973) described by Raleigh as a milestone on the route to the lake.

Thomas Harriot's map

The making of a second map under Raleigh's guidance is ascribed to Thomas Harriot, a famous mathematician and cartographer of his time as well as a protégé of Raleigh's. In this map (Fig. 22), it is speculated that Harriot added some observations to the information on Raleigh's "Main chart" (Fig. 21). Captain Lawrence Kemys made reference to these observations on his second voyage to Guiana in 1596 (Nicholl 1995). Raleigh had entrusted Kemys with the exploration of inland Guiana which Kemys undertook by sailing up the Caroni River (Kemys 1596) . He reached the Paragua River where we know one of his ships was wrecked in a rapid.

Fig. 22. Thomas Harriot's map showing the connection between Manoa Lake and the Essequibo River (Drawing © José Miguel Pérez -Gómez & Charles Brewer-Carías.)

His map is believed to have been made in 1596 and delivered to the 9th Earl of Northumberland (known as "The Wizard Earl" for his intellectual reputation) who was imprisoned in the Tower of London from 1605 to 1621 for supposed complicity in the Gunpowder Plot. While there, it is believed Northumberland shared impressions with Raleigh, himself imprisoned in the Tower for three years for secretly marrying one of the Queen's ladies-in-waiting without royal consent. Surpassing Raleigh's map, Harriot's remained hidden for nearly 400 years. It then appeared briefly in 1928 but promptly disappeared again until 1990 when it resurfaced in a Sotheby's auction catalogue (Sotheby's 1990; Nicholl 1995) listed as property of the heirs of the 9th Earl of Northumberland. It was then, it is supposed, purchased by a Venezuelan collector. Unlike the previous map, Harriot's shows a connection between the *Essequibo* River (written as *Desakeby*) and Lake Parime, which is one of the conclusions Captain Kemys reached after his second voyage in search of the lake. Another detail meriting emphasis is the branching Harriot gives the Caroni River into two main courses: the Caroni and the Paragua Rivers. It is a rendering lacking on Raleigh's earlier map.

Jodocus Hondius, Cartographer

In spite of the fact that Raleigh was the main promoter of Lake Parime and the city of Manoa and in spite of producing his highly meticulous, extraordinary map, he was ironically not the first to publish it. Its first known publication was by the Dutch cartographer Jodocus Hondius in 1599 (Hondius 1599; Corpoguayana 2000). It is worth noting that the word *Guiana* appears on it for the first time (Fig. 23) on any map. It is believed that Hondius produced his map based on a copy of Raleigh's which the cartographer had obtained while living in London. Some scholars suggest that a copy of one of Raleigh's earlier maps was in William Downe's possession. Downe was master of the ship *Discovery* during the second of Captain Lawrence Kemys's expeditions to Guiana in 1596. (Kemys 1596)

An interesting detail shown in this map are the images of the *Amazona* and the *Ewaipanoma* (Von Hagen 1974) imaginary beings "...reported to have their eyes in their shoulders, and their mouths in the middle of their breasts, and that a long train of haire groweth bacward betwen their shoulders." These beings were described by a chieftain on the lower Orinoco to Raleigh as living on the Caura River and are referred in *The Discoverie* (Harlow 1928; Kemys 1599). Unlike Harriot's foregoing map based on the observations of Lawrence Kemys, this map does not show a connection between Lake Parime and the *Esequibo* River. Its scale is 1:6,500,000 and its dimensions are 36.5 x 52.5 cm.

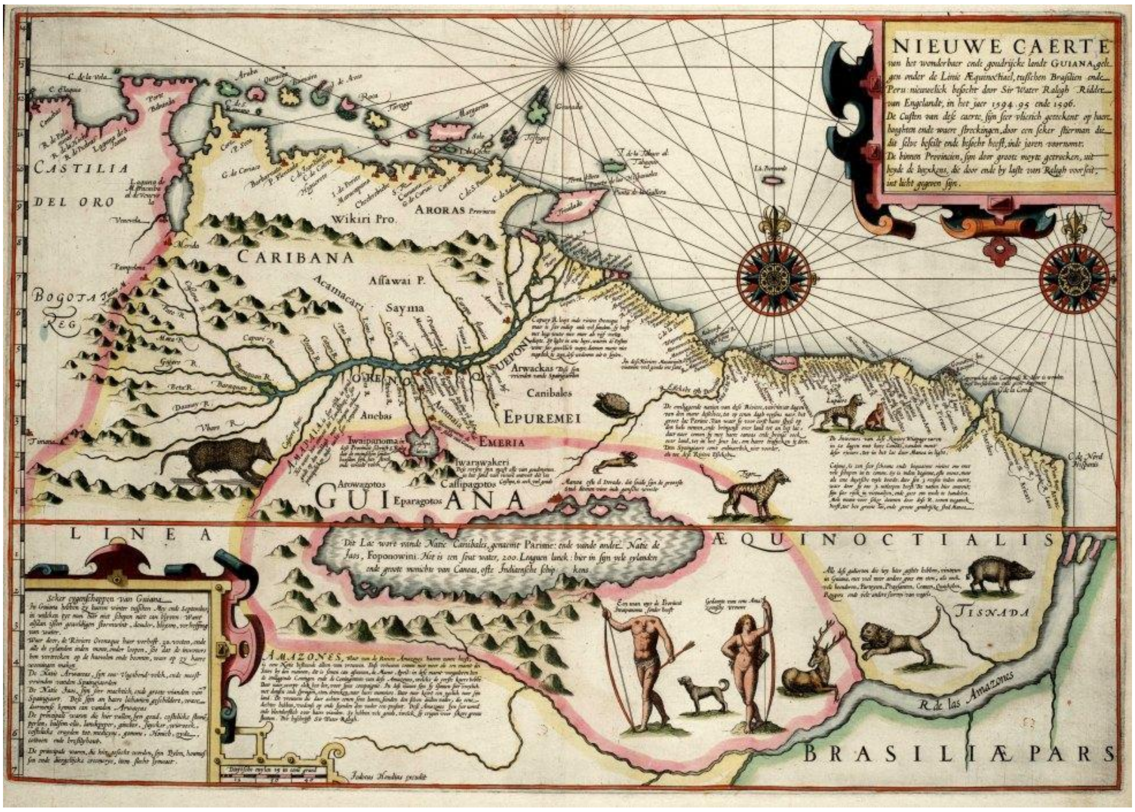


Fig. 23. Engraving by Jodocus Hondius, 1598. (Image source: Geheugen.nl.)

Theodore de Bry's map

This same year, 1599, another map—a copy of the foregoing made by Jodocus Hondius—appeared attached to volume VIII of a work entitled *Great or American Voyages* published by the famous Belgian engraver Theodore de Bry (Fig. 24). (Sothebys 2016). The map, in ink, appears folded in at the end of this volume. As a result of studying the same, we concluded it is in fact a somewhat imprecise copy of the Hondius map (Hondius 1599) lacking several details.

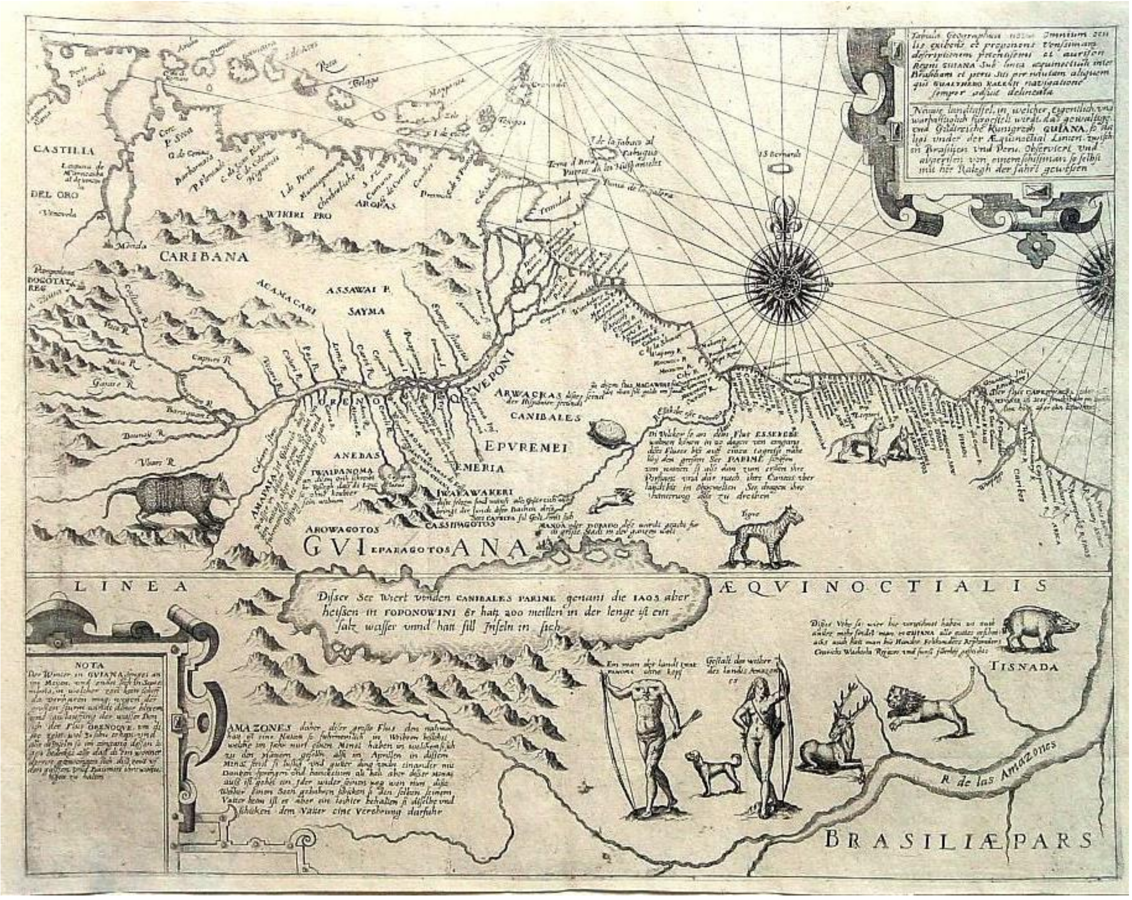


Fig. 24. Map of Guiana by Theodor de Bry from the *Great or American Voyages* which reprints the accounts of Raleigh, Drake, and Cavendish. Frankfurt, 1599. (Image Courtesy of Arader Galleries.)

Hessel Gerritsz's map

As these maps attest, and for almost four hundred years thereafter, the notion of a Lake Parime remained embedded in South American geography. Its shape varied but its location was constant: in Guiana (Fig. 25) between the Orinoco and Amazon Rivers. Dutch cartographer Hessel Gerritsz was the apprentice of Willem Jans Blaeu. He played a crucial role in the cartographic activities of the West Indian Company which he provided with maps and rutters of the coastal waters of Latin America (Schilder 1985). In his 1625 map of Guiana, most probably copied from predecessor maps, Lake Parime is once again the main element although displaced eastwards, perhaps as a result of the unfruitful efforts to locate it.

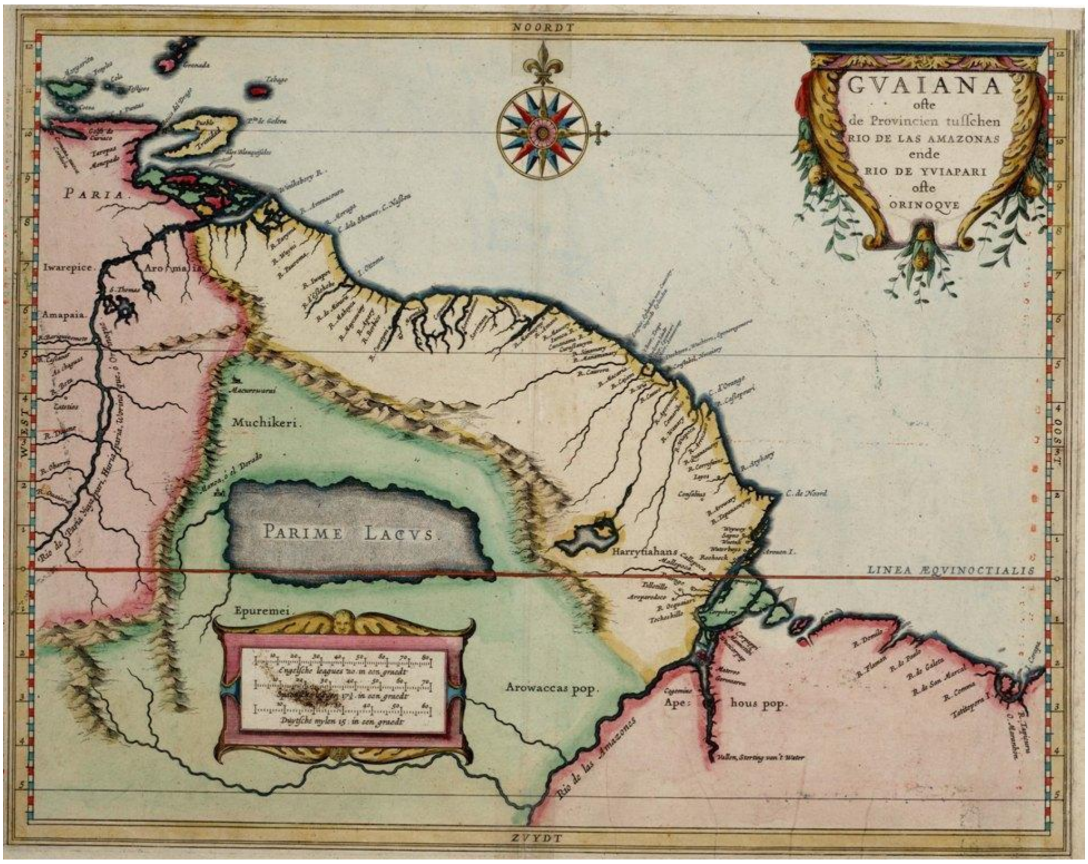


Fig. 25. Hessel Guerritz, 1625 map with Lake Parime displaced into British “Guaiana” territory. (Image © The British Museum).

Henricus Hondius’s map

Henricus and Jodocus II were sons of Jodocus Hondius. The America Meridionalis map(Fig. 26) was published under the Henricus Hondius imprint beginning in 1619.

Fig. 26. The Henricus Hondius America Meridionalis map of 1630. (Image © Pinterest.)

Henricus appears to have been heavily involved in the map from 1619 until 1633 when his brother-in-law's name and imprint, that of Johannes Janssonius, also started appearing on the work. After 1636 the name of the map was changed to *Atlas Novus* with Janssonius mainly responsible for its publication (Koeman 1961). This extraordinary map, made by Henricus Hondius in 1630, shows highly detailed South American coastline as well as the inevitable image of Lake Parime. Even though explorers from the 16th and 17th centuries into the 19th failed to find this elusive place, there is no doubt their eager quest helped populate South America during this period. As on all previous maps, once again Lake Parime is situated on the equator because as everyone knew, gold "grows" best at that latitude.

James Wild's map

This is yet another map evidencing the determination of many cartographers to continue placing Lake Parime in the Venezuelan Guiana over three hundred years after the first map was published. James Wild produced this work in 1829 (Fig. 27). Two features stand out: the South American coast has been further defined, and the heretofore monumental size of Lake Parime is here reduced to moderate dimensions.

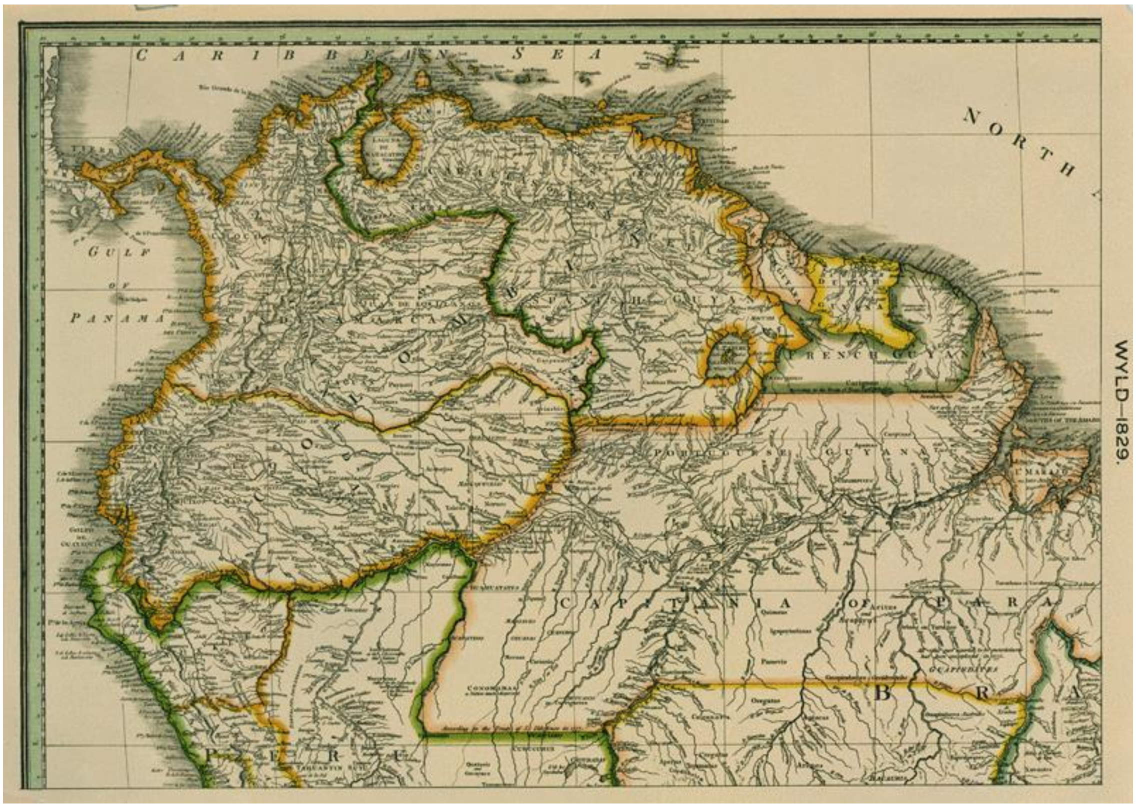


Fig. 27. James Wild's map of 1829 depicting a smaller Lake Parime—perhaps because it had still not been found. (Image © Vialibri.)

Appendix II
Preliminary Evaluation of the Artifact Assemblage

Pottery and its origins have been crucial tropes in cultural histories since ancient times. Ceramics have contributed rich images and metaphors to express the ineffable experiences of Homo sapiens. An example is the Biblical account of the creation of humanity from clay through birth, life, sexual experience, and death (Rice 1999). Myths of many contemporary South American groups refer to clay, pots, and potters, along with birds and vines in association with earthly creation and cosmic struggles (Rice1999). For instance, in the *Popol Vuh*, the book of the “dawn of life” of the Quiche Maya in highland Guatemala, the gods *Tzakol* and *Bitol* create the earth and its plants and creatures. Glossed as “Maker” and “Modeller,” these gods’ names derive from verbs indicating the making of shapes such as pottery vessels out of formless, pliable materials like clay (Tedlock 1985).

As material, tool, and technology, pottery represents a sophisticated merging of previously separate domains of human knowledge and experience: resources, technological processes, and needs. More specifically, these come down to clay, fire, and containment. Discovery of the changes wrought in clay when fire is applied has been recognized since the late nineteenth century as a significant technological advance (Rice 1999). The vast tropical rainforest in Amazonia, once presumed a virgin wilderness vulnerable to climate forcing and inimical to indigenous cultures, is now shown by prehistoric, ethnographic, and ethno historical data to be almost the opposite of this: a human habitat resistive to significant environmental alteration but nevertheless much influenced by thousands of years of occupation. The earliest foragers quickly penetrated the region ca. 13,000 years cal BP, leaving traces far and wide. The first villages, ca. 4000 years cal BP later, created substantial shell-middens and disturbances in nearby forest areas. After another 4000 years cal BP in many regions, people turned to shifting horticulture: cutting and burning fields, disseminating crops, and planting trees. In the final 3000 years of prehistory, networks of populous and warring chiefdoms established nucleated centres on floodplains and along trade routes. They created mound complexes, defence works, fields, orchards, and refuse heaps which greatly altered topography, soils, and vegetation (Roosevelt 2014).

The origin of ceramic technology in the Americas has long been a source of debate. The adoption of ceramics has frequently been interpreted as an important step toward the emergence of complex societies (Hoopes 1994). Spinden’s was but one of the first in a long line of diffusionistic models. By the mid-1960s, early dates suggested that the origins of New World ceramic technology were to be found not in Mexico but in South America (Hoopes 1994). In addition, Spinden argued that regionally specialized cultures emerged from a common base of village farming and suggested that both pottery and early agriculture diffused north and south in the Americas from an ancient hearth in Mexico. The advent of carbon dating helped anchor complexes in time, confirming that pottery use had begun at least as early as 3000 B.C. (Hoopes 1994). While recognizing that ceramics and early agriculture did not always go hand in hand, Willey and Phillips emphasized pottery as an important component of early settled communities in the Formative stage.

Local pottery was traded into the Andes and shell from the Pacific into the lowlands. The dates of the Ecuadorian mounds are Formative, between about 2500 and 1400 years ago, which is the period when pottery was introduced from Amazonia to the Andes (Roosevelt 2014). Recently the upper Orinoco area has become the center of archaeological interest and debate thanks to data from recent excavations. In any case, the two oldest ceramic series of the Orinoco, *Saladoide* and *Barrancoide* (Cruxent & Rouse 1982), could derive from an older site named *La Gruta*. This site, discovered during the 1970s in the Middle Orinoco, originated some 4000 years ago (Zucchi et *al* 1984) thus making it one of the earliest Formative sites in the whole of Amazonia.

An archaeological site was discovered in an area inhabited by the Yanomamö indigenous people in the year 1990 within the context of an anthropological expedition to the southern part of Venezuela. The site contained distinct types of artifacts including pottery shards, beads, and lithic as well as debitage fragments. Although neither thermoluminescence (TL) nor C-14 dating techniques have been performed on the assemblage, it is interesting to note that in view of some of the reconstructed pottery styles, this assemblage could be much older than initially thought. Evaluation of the lithic artifacts suggests the Meso-Indian cultural period. Some of the pottery fragments also show temper inclusions similar to siliceous spicules which perhaps are of organic origin. These are used to reduce shrinkage and enhance fracture resistance. They likely can be associated with a wider Amazonian cultural region related to pre-Columbian ceramist occupations. Those occupations used the same temper inclusion technique and date roughly from 1500 B.C. up to the time of the European Conquest (Natalio et al 2015).

Preliminary technological and formal functional analyses have been performed on the ceramic and lithic assemblage collected from the study area. Both macroscopic and microscopic aspects of the assemblage have been assessed using archaeometric techniques aided by the use of a digital camera, calibrated callipers, a guide for estimating vessel diameters, and an electronic scale for weight measurements. In addition, some digital reconstructions have been performed. Although, as mentioned above, the assemblage requires further study, preliminary analysis is relevant for two reasons. First, these artifacts are already contributing to archaeological knowledge and discussion of the ceramic and lithic technologies employed by Amazonian pre-Columbian groups. Second, they bring to light a new site significant to the archaeological record in this part of Amazonia.

The Archaeological context

Cultural landscapes are environments that have been altered in some manner by people. They include temporary structures such as campsites (Spencer-Wood & Baugher 2010). Our study area is situated close to a river in a large and remote jungle area of the upper Orinoco River with no apparent landscape modifications. Observations in situ suggest that this location could be a much larger archaeological site than initially believed because the exposed area corresponds only to a *Shabono's* inner clearing. The aerial image (Fig. 28) shows where the Yanomamö *Shabono* was located and where the assemblage was collected. A detailed map was also prepared (Fig. 29) indicating bearings and showing the position where most of the

Fig. 28. Aerial photo where the Yanomamö shabono was located in 1990 and where the assemblage of artifacts was collected. (Image © Jose Miguel Perez Gomez).

artifacts were positioned. Since the *Shabono* is currently extinct, this information will help to locate them on a future survey to the study area.

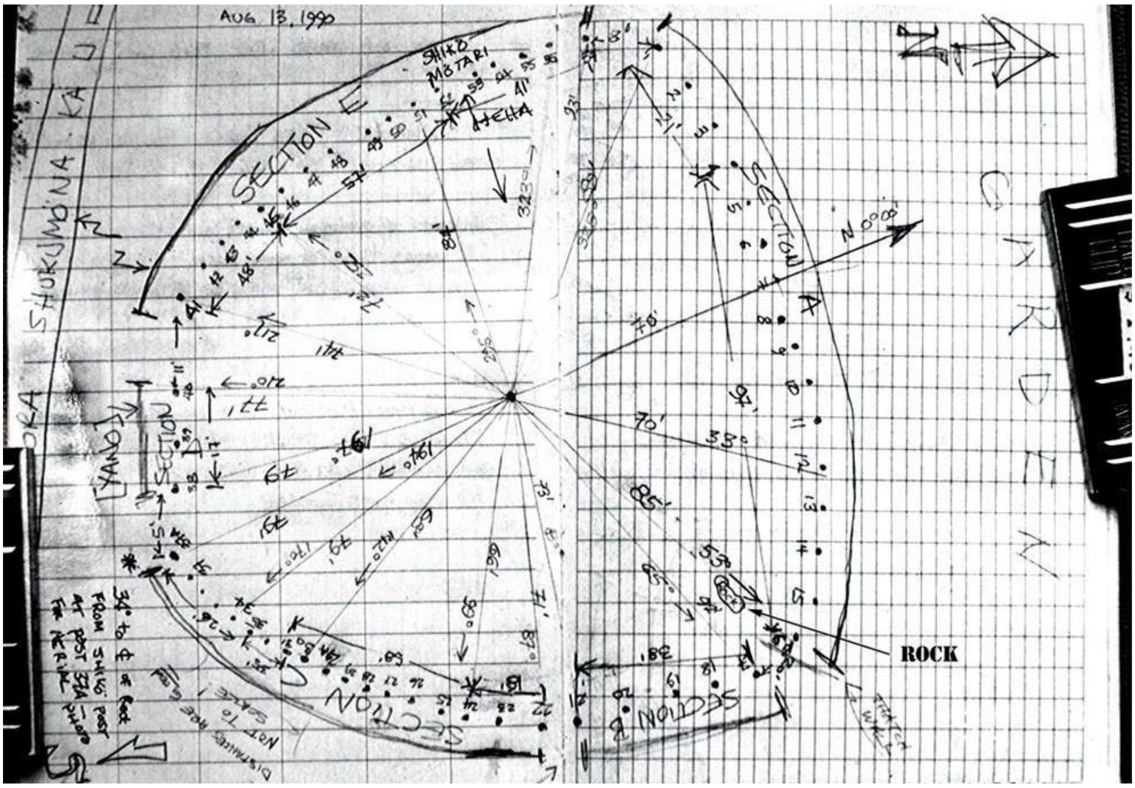


Fig. 29. Field notebook of Napoleon Chagnon showing the shabono orientation and the rock position used to locate artifacts context within the shabono area. (Image © Charles Brewer-Carías)

The few investigations carried out in the Upper Orinoco were concentrated near the *Atures* rapids in the north of the state of Amazonas until the first half of the twentieth century. Cruxent was the first to establish a ceramic style at *Cotua* Island, where petroglyphs and lithic workshops were also located (Cruxent 1950). The *Cotua* style was assigned to the Saladoid series although it shares many elements with the Barrancoid series (Gasson 2002). Two pre-ceramic components were defined as *Atures* I and II at the Culebra site much further upriver. The *Atures* I component is characterized by flake scrapers, flake cores, and debitage of local quartz and quartzite. The Atures II component consists of flake scrapers and debitage similar to Atures I. However, it also includes tanged projectile points of chert which could have originated in the interior of the Guiana Shield. These projectile points show similarities to the Canaima Complex (Cruxent 1972; Gasson 2002).

The studies performed on the pre-ceramic components and their associated dates have served to define the Atures tradition over the Archaic period in *Orinoquia*. This tradition is comprised of two periods: Atures I (9200-7000 B.P.), which includes flakes and scrapers associated with the initial adaptation to the tropical forest; and Atures II (7000-4000 B.P), distinguished by the presence of projectile points and flakes associated with adaptation to the savannas and forests that emerged with the drier climate in the middle and late Holocene (Barse 1995). Such findings would seem to indicate the great antiquity of two typical Orinoquia patterns: the exploitation of different ecological zones and the connection between highlands and lowlands.

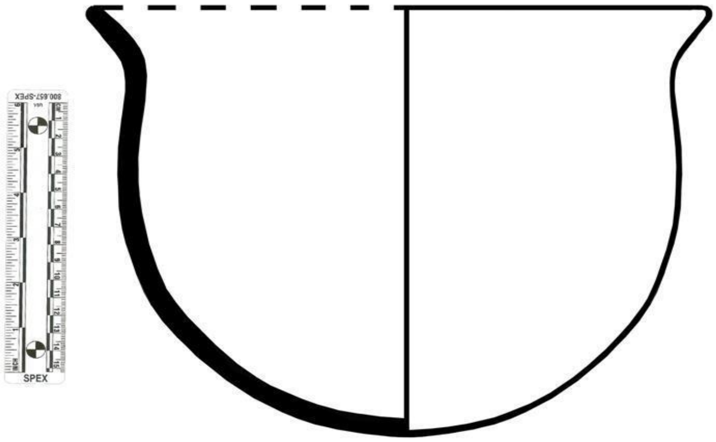
The ceramic sequence ranges from 3500 to 720 B.P. (Gasson 2002). Two phases are identified in the Orinoco. The first is the *Galipero*, consisting of potsherds and hyaline quartz flakes similar to those of the Archaic period. These ceramics, tempered with small clay pellets and lacking decoration, are likely related to the *Cedenoid* series of the Middle Orinoco River. The second phase, *Isla Barrancas*, features sand-tempered ceramics. Forms include flanged hemispheric bowls and flanged plates with hollow rims, red painting, simple incision, modeled-incised buttons or nubbins, and zoomorphic ornaments. These second-phase ceramics were recovered beneath sterile silt loam and are dated 2600-1765 B.P. All three examples constitute reddish, sand-tempered ware decorated with wide and flat incisions associated with the less common *cauixi- or caraipe*-tempered ware (Gasson 2002).

Cruxent and Rouse attributed the origin of the Barrancoid series (deriving from Isla Barrancas) to the lower llanos, rejecting the hypothesis of the Middle Amazon River. Regardless, other authors such as Barse see no evidence that the Barrancoid tradition developed in *Orinoquia*. They hold that the existence of an earlier phase such as the *Galipero* would appear to indicate that earlier Formative phases were already in place before the *Barrancas* tradition arrived in the upper Orinoco area (Barse 1999). Next images, 30 to 46, corresponds to the preliminary analysis of the artifacts assemblage collected in 1990 at the study area.

Images and Digital Reconstruction of Assemblage Artifacts found at the Study Area 2

Fig. 30. Potsherds. Field Tag SR/90-01. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez)

Field tag: SR/91-01
Number of Shards: 11
Weight: 560 gr.
Category: Coarse Earthenware
Function: Cooking bowl
Mouth Diameter: 30 cm.
Height: 25 cm.
Wall thickness: 1.2 cm.



Observations:
Paste of the shards exhibits medium to fine sand temper with larger inclusions ranging from 1 to 3 mm. Medium compaction is noted with a poorly smoothed surface evidencing a pallid white colour on the exterior. No throwing ridges are perceived but instead what appear to be some slight decoration lines. The inner core of the fabric evidences a dark gray paste, possibly organic, which can be appreciated on the interior of the vessel as well**.**

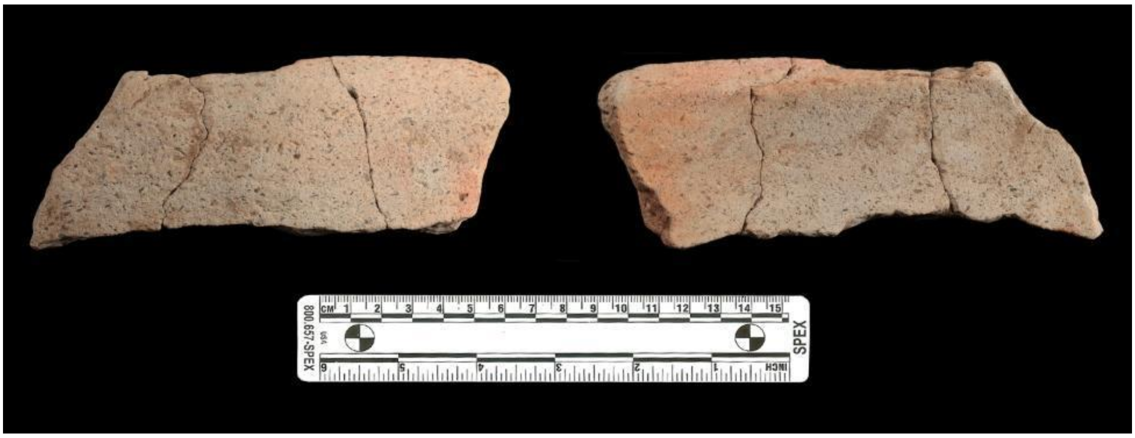
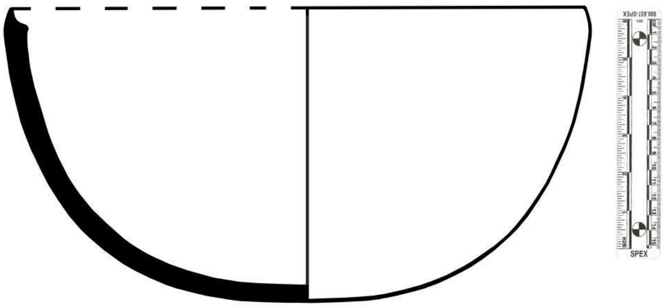


Fig. 31. Potsherds. Field Tag SR/90-02. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez)

Field tag: SR/91-02
Number of Shards: 3
Weight: 161 gr.
Category: Coarse Earthenware
Function: Cooking bowl
Mouth Diameter: 40 cm.
Height: 18 cm.
Wall thickness: 1.5 cm.



Observations:

Paste of the shards exhibits medium to coarse sand temper with large inclusions similar to "*spicules*" ranging from 1 to 4 mm. These inclusions (*) are particularly interesting since they could have been added intentionally to make a stronger and lighter vessel (Fig. 32). These shards show medium compaction with a poorly smoothed surface of pallid white, perhaps weathered, on exterior and interior; throwing ridges are noted. The inner core of the fabric reveals a light gray paste. No organic content was found on the interior of the vessel**.** Profile shape suggests that this vessel could have been associated with a lid cover.

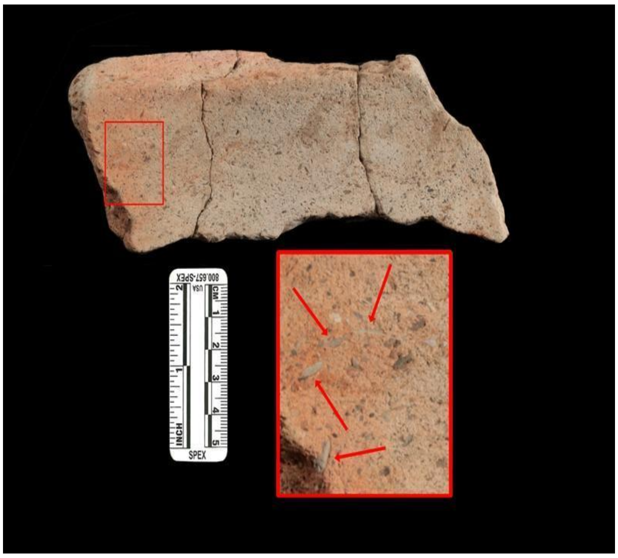


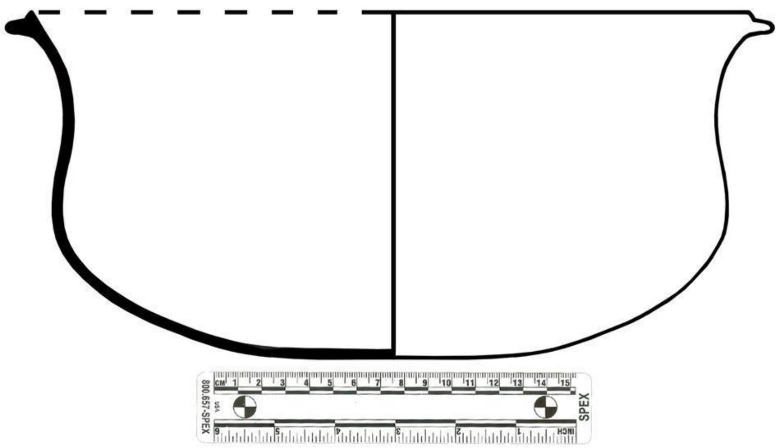
Fig. 32. Potsherds SR/90-02 showing the presence of inclusions (Image © Charles Brewer Carías and José Miguel Pérez-Gómez.)

(*) Detailed pictures of inclusions are evaluated and preliminarily assessed in the current research.

Fig. 33. Potsherd. Field Tag SR/90-03. Image and reconstruction drawing
(Images © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-03

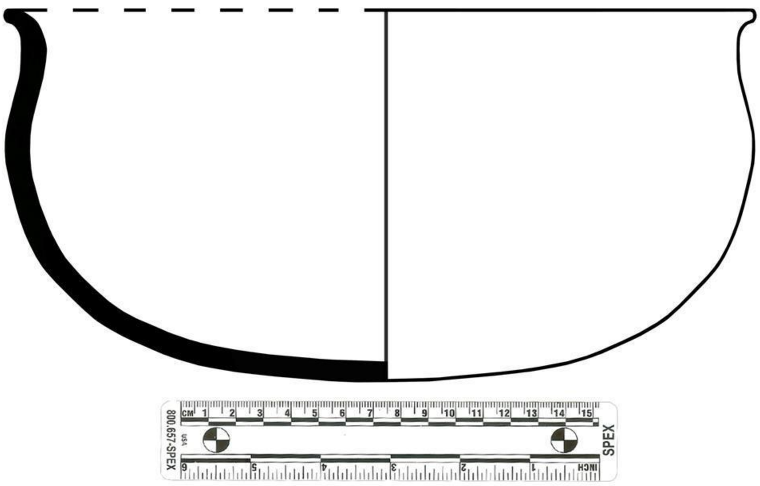
Number of Shards: 1
Weight: 55 gr.
Category: Coarse Earthenware
Function: Cooking bowl
Mouth Diameter: 30 cm.
Height: 15 cm.
Wall thickness: 0.8 cm.



Observations:
Paste exhibits a fine sand temper with almost no inclusions as well as high compaction with a well-smoothed surface featuring dark red terracotta colour on the exterior. No throwing marks are noted; there is a decoration line below the lip. The inner core of the fabric features a light brown paste. Organic content is found on the interior of the shard.

Fig. 34. Potsherd. Field Tag SR/90-04. Image and reconstruction drawing
(Images © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-04
Number of Shards: 1
Weight: 101 gr.
Category: Coarse Earthenware
Function: Cooking bowl
Mouth Diameter: 27 cm.
Height: 14 cm.
Wall thickness: 1.0 cm.

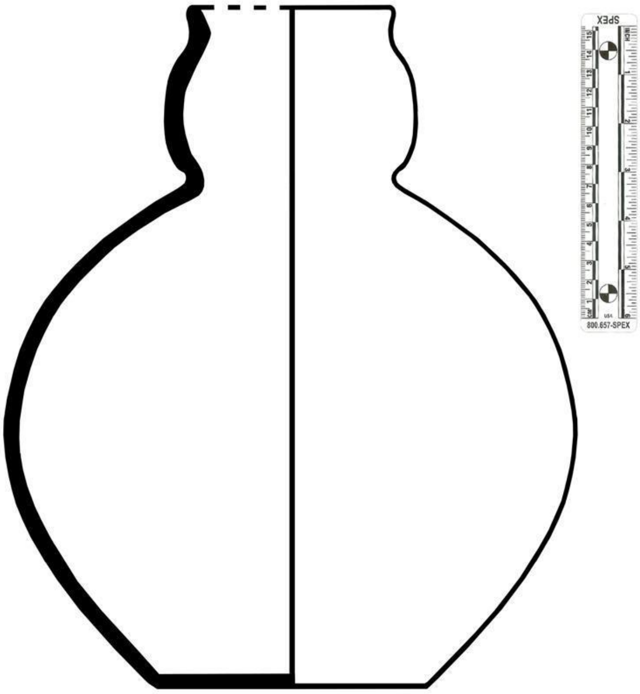


Observations:
Shard paste features medium sand temper with inclusions ranging from 1 to 3 mm. Poor compaction is evidenced with fair smoothed surface of light red terracotta colour on the exterior. Neither throwing marks nor decoration lines are present. The inner core of the fabric shows a light reddish paste. Some organic content is present on the inner side of the shard**.**

Fig. 35. Potsherd. Field Tag SR/90-05. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-05

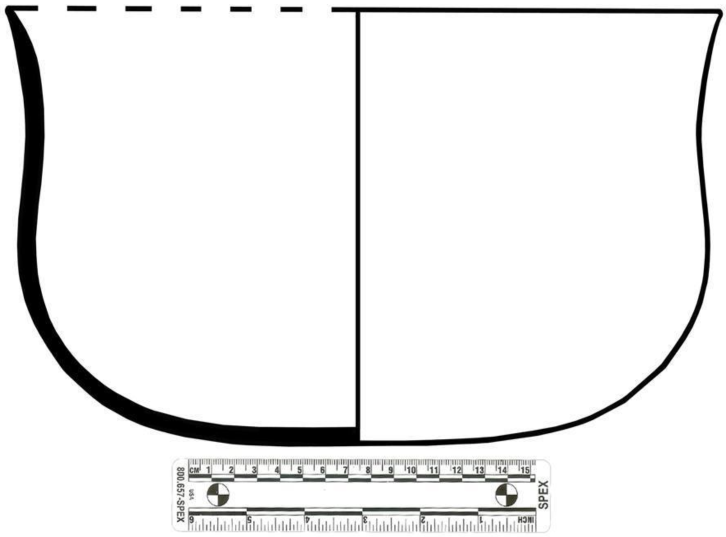
Number of Shards: 2
Weight: 122 gr.
Category: Coarse Earthenware
Function: Water container
Mouth Diameter: 8.7 cm.
Height: 35 cm.
Wall thickness: 0.9 cm.



Observations:
Shard paste features fine sand temper with inclusions ranging from 1 to 3 mm. Noted also is high compaction with a fair smoothed surface and a light brown terracotta color on the exterior with remains of white paint. Neither throwing marks nor decoration lines are present. The inner core of the fabric is of the same color as the exterior. No organic content is present.

Fig. 36. Potsherd. Field Tag SR/90-06. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-06
Number of Shards: 1
Weight: 45 gr.
Category: Coarse Earthenware
Function: Cooking bowl
Mouth Diameter: 30 cm.
Height: 18 cm.
Wall thickness: 0.6 cm.



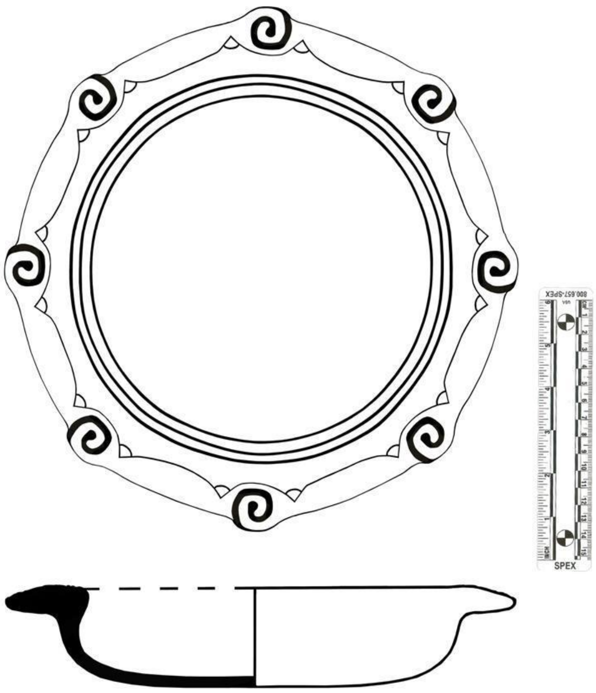
Observations:
Shard paste exhibits coarse sand temper with high number of inclusions ranging from 1 to 6 mm. evidencing poor compaction with rough finished surface; the exterior is of light brown terracotta color. Neither throwing marks nor decoration lines are present. The inner core of the fabric features the same color as the exterior. No organic content is evident.

Fig. 37. Potsherd. Field Tag SR/90-07. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-07

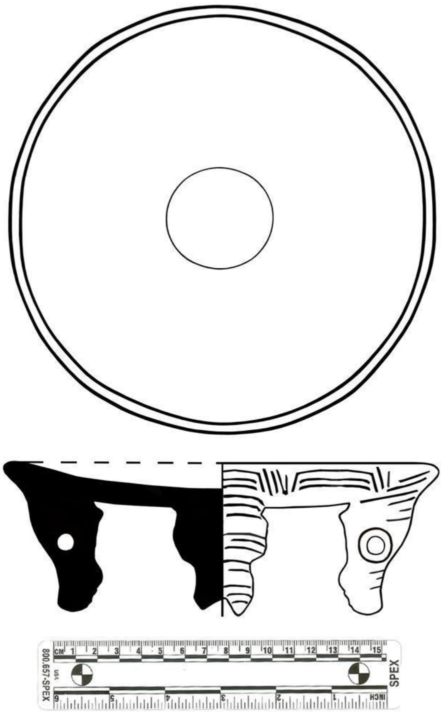
Number of Shards: 1

Weight: 29 gr.
Category: Coarse Earthenware
Function: Shallow bowl
Mouth Diameter: 20 cm.
Height: 6 cm.
Wall thickness: 1.1 cm.



Observations:
Shard paste exhibits fine to medium sand temper with a large number of inclusions ranging from 0.5 to 1 mm. Noted are poor compaction and a rough finished surface decorated with white color on the exterior. Decoration lines in bas-relief are present. The inner core of the fabric features a gray paste color. No organic content is present. This fragment is too small to generate a conclusive reconstruction drawing.

Fig. 38. Potsherd. Field Tag SR/90-08. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)



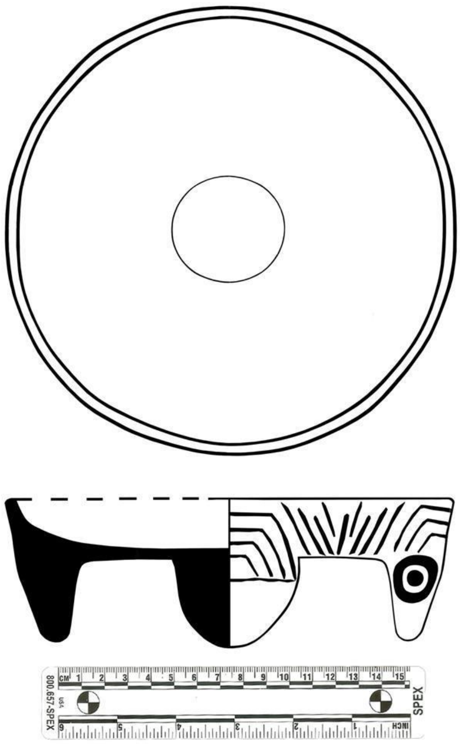
Field tag: SR/90-08
Number of Shards: 1
Weight: 62 gr.
Category: Coarse Earthenware
Function: Ceremonial Tripod Bowl
Mouth Diameter: 20 cm.
Height: 6.4 cm
Wall thickness: (n/a)

Observations:
Paste of the fragment features fine to medium sand temper with inclusions ranging from 0.5 to 1 mm. resulting in poor compaction. A rough finished surface displaying a light red terracotta color and decoration with some dark lines on the exterior is evidenced. Decoration lines seems to be in bas-relief. The inner core of the fabric exhibits a dark brown paste color. No organic content is evident.

Fig. 39. Potsherd. Field Tag SR/90-09. (Image and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-09

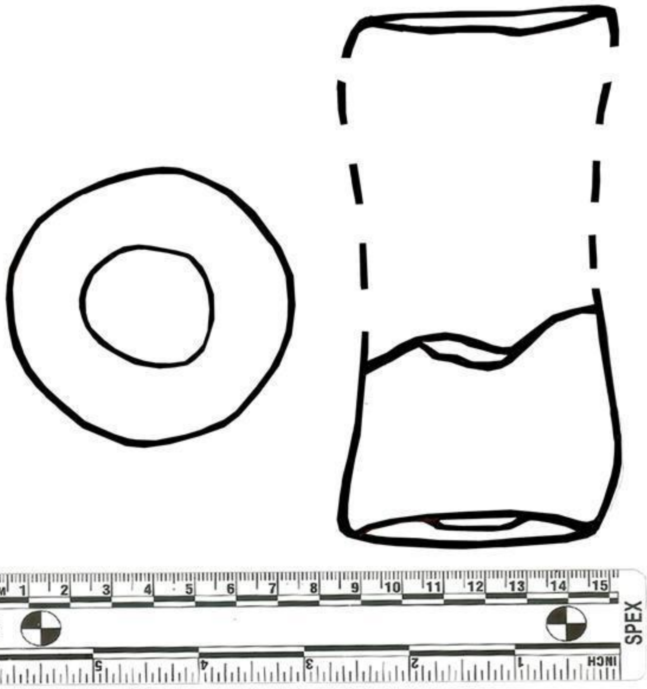
Number of Shards: 1
Weight: 50 gr.
Category: Coarse Earthenware
Function: Ceremonial Tripod Bowl
Mouth Diameter: 20 cm.
Height: 6.3 cm
Wall thickness: (n/a)



Observations:
Paste of the fragment has fine to medium sand temper with inclusions ranging from 0.5 to 1 mm. evidencing poor compaction with a rough finished surface of a light brown color. White color seems to have been applied to the shard; bas relief lines appear on the exterior. The inner core of the fabric exhibits a dark gray paste color. No organic content is present.

Fig. 40. Potsherd. Field Tag SR/90-10. (Images and reconstruction drawing © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

Field tag: SR/90-10
Number of Shards: 1
Weight: 246 gr.
Category: Coarse artifact
Function: *Budare* base?
Mouth Diameter: 6cm
Height: 6 cm
Wall thickness: (n/a)



Observations:
Distinct types of paste ranging from fine to high sand temper showing distinct sizes of inclusions and poor to medium compaction with rough finished surface. No decoration or color is evidenced. First sight suggests a brick. However, the piece is rounded. It is possible this piece comprised part of the kiln process, acting as a spur to hold vessels during a burn. No organic content is evidenced.

Other types of isolated shard profiles evidenced in the Assemblage:

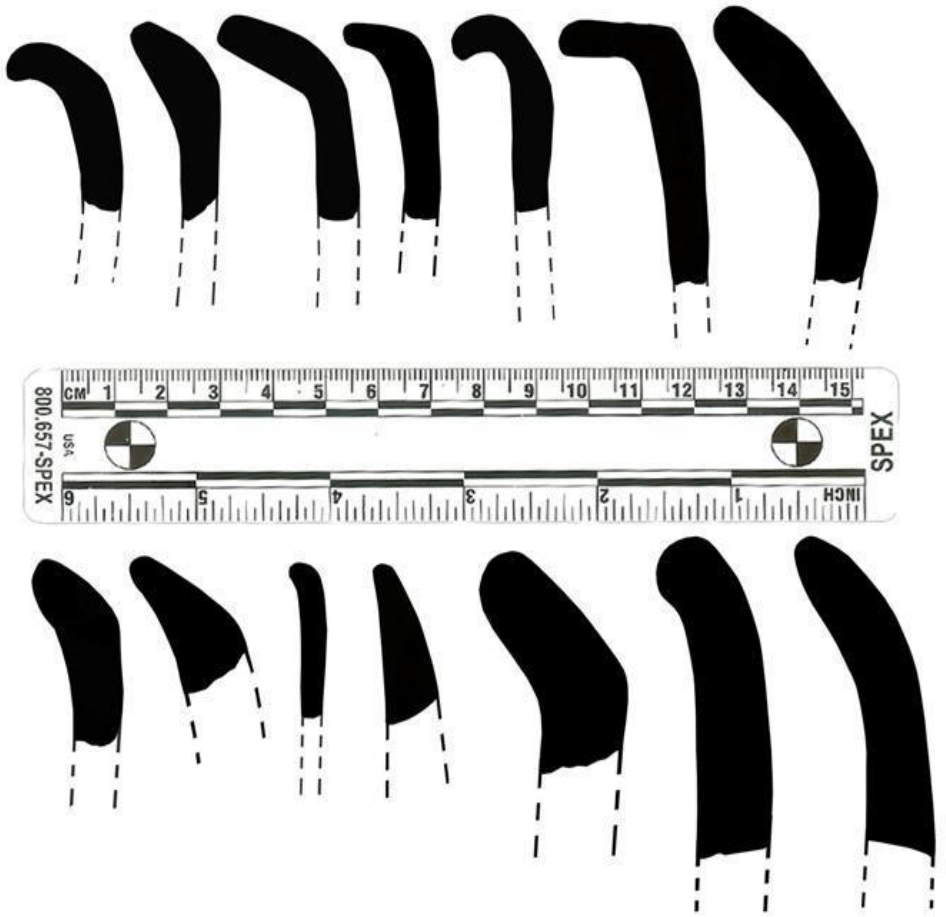


Fig. 41. Potsherd Profiles. Field Tag SR/90-11. (Reconstruction drawing and image © José Miguel Pérez-Gómez)

Field tag: SR/90-11

Number of Shards: 14
Weight: 246 gr.
Category: Coarse Earthenware
Function: Distinct vessels
Mouth Diameter: (n/a)
Height: (n/a)
Wall thickness: (n/a)

Observations:
Distinct types of paste ranging from fine to high sand temper showing inclusions in most cases; poor to medium compaction with rough finished surface. No decoration or color is evidenced except for a single piece showing decorative lines as well as white color on both the exterior and the interior of the shard. The inner core of the fabric shows paste color ranging from red terracotta to dark gray. No organic content is evident.

Inclusions evidenced in clay temper

The concept of combining materials with different properties such as composites goes back to prehistoric times. Given its natural abundance and workability, clay has been the material of choice for producing utilitarian pottery and culturally expressive ornaments. This is extensively documented in archaeological records. Be that as it may, the inferior mechanical properties of clay created the need to incorporate inclusions (Fig. 42) either inorganic (e.g. sand, sponge siliceous spicules, ground potsherds, mica, grog, and ashes) or organic (e.g. grass, dung and straw). These reduce shrinkage and enhance resistance to fracture (Natalio et al 2015)

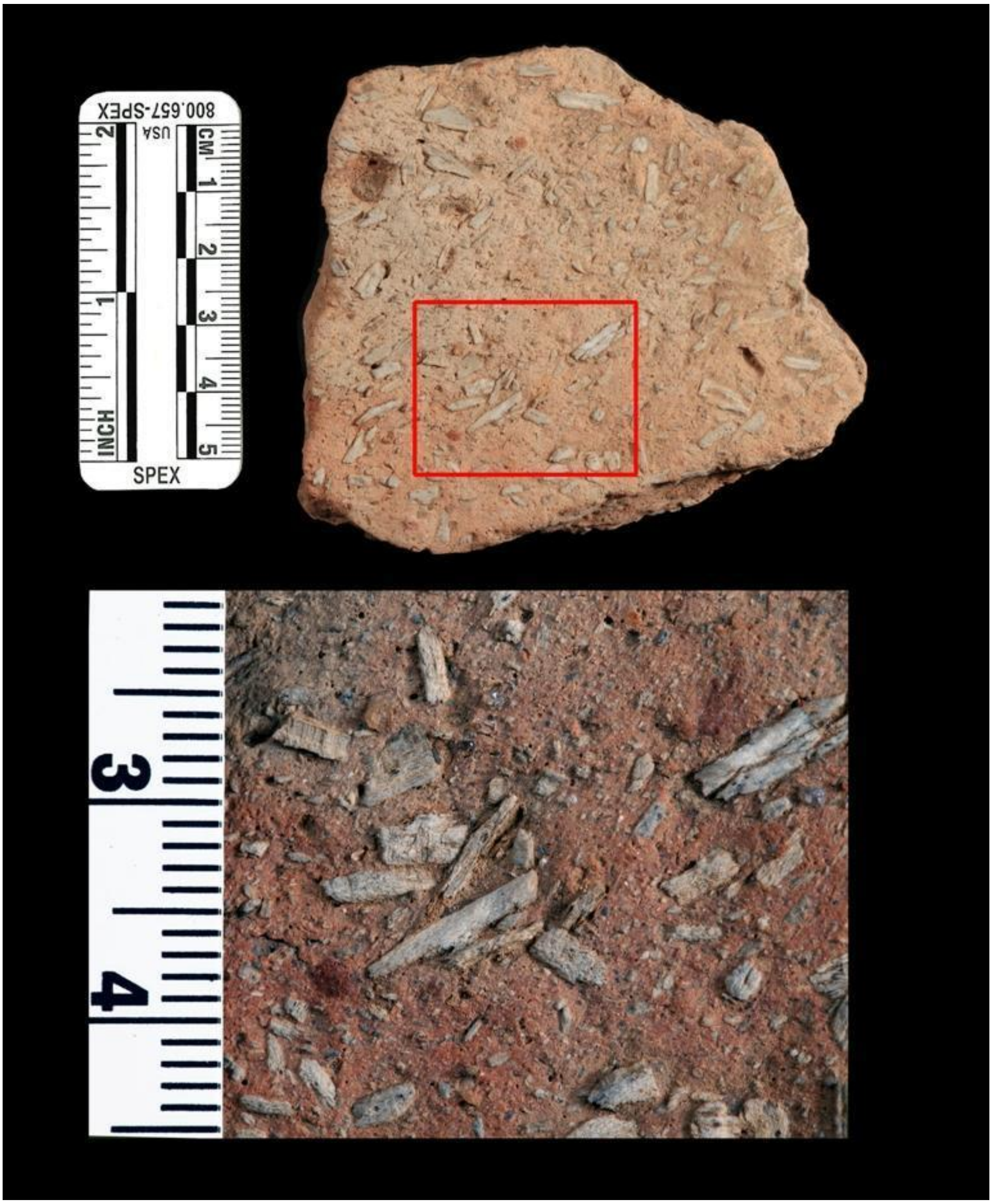


Fig. 42. Inclusions observed on a potsherd fragment from the study area. (Images © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

The extensive pre-colonial Amazonian pottery archaeological record shows a clear and intentional use of inorganic inclusions such as shells, the siliceous spicules of tree sponge (*cauxí*, i.e. Demospongiae, Drulia sp.), the ground ashes of bark from *caraipé* (Licania sp.), as well as shells and grog. The use of *cauixí* was widespread by pre-Columbian ceramist occupations in Amazonia (ca. 1500 B.C. to the European Conquest), although its use seems to have decreased or even ceased in many areas over time (Natalio et al 2015). Despite the fact that the inclusions evidenced in the shards from the study area have not been studied in detail, it is evident that according to the prepared thin sections, the same might be of organic origin (Fig. 43). Nonetheless, further studies are merited.

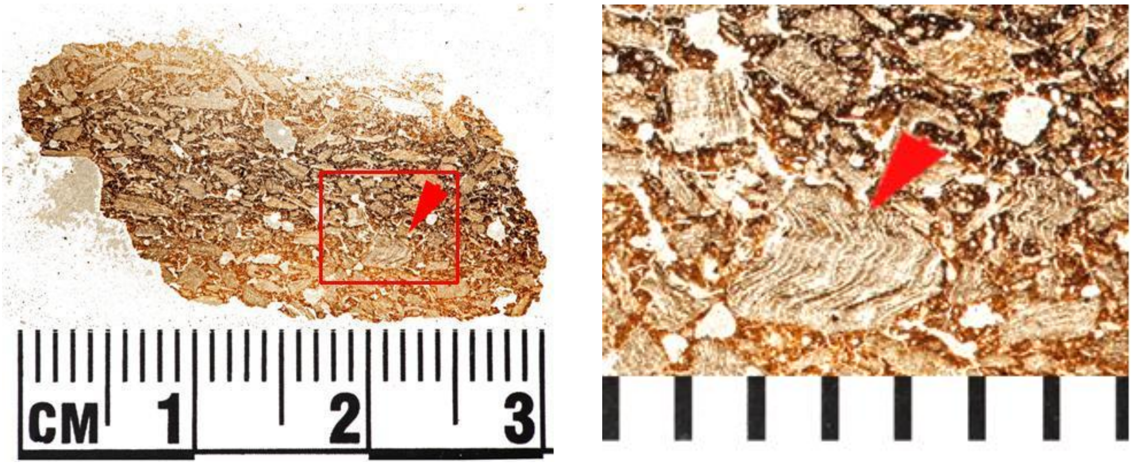
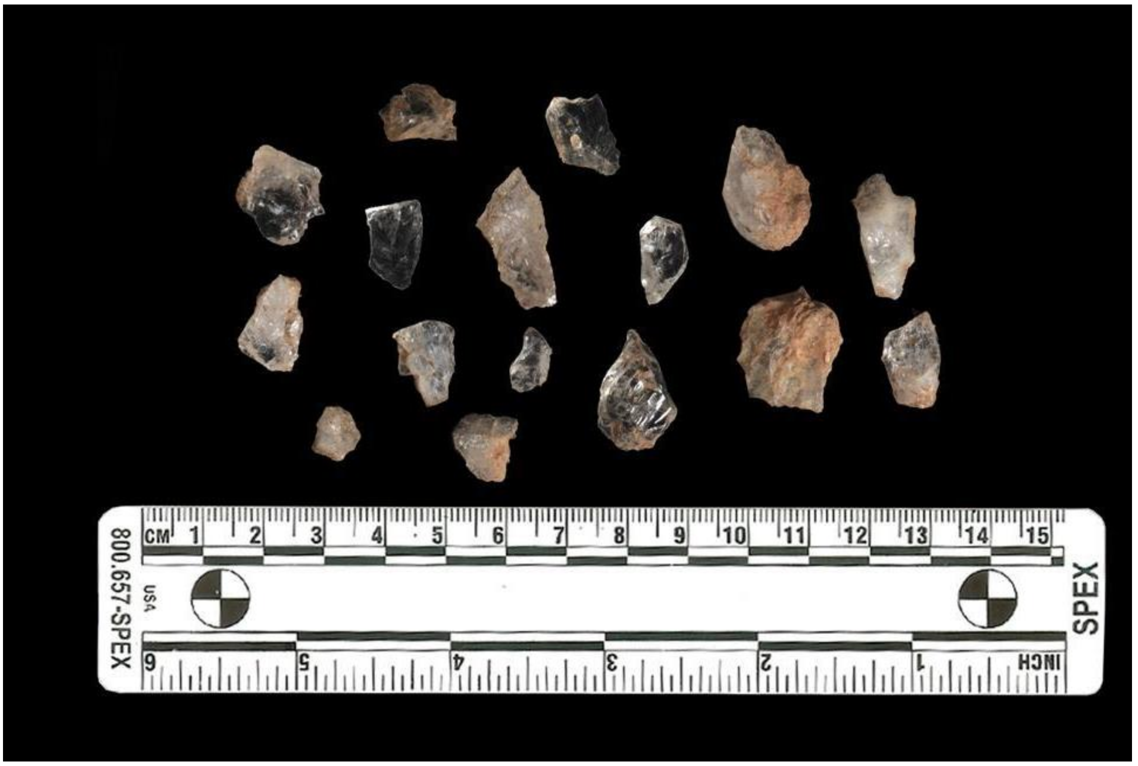


Fig. 43. Thin section of a potsherd fragment from the study area showing a transversal cut of an inclusion which, on taking into account its characteristics, might suggest an organic origin. (Images © Charles Brewer-Carías and José Miguel Pérez-Gómez)

Lithic artifacts

Stone tools appeared between two and three million years ago in African sites and dominate the Paleolithic record. Because of their durability, they have provided archaeologists with a framework for Mesolithic archaeology as well. They play a key role in early archaeological studies generally. Without stone tool research, archaeology would not have acquired the understanding the field in fact possesses of early human social and economic organization, not to mention the development of human cognition and technology. Traditionally, archaeologists have incorporated human behaviour into their interpretations by identifying feature and artifact functions (Andrefsky 2010). Determining whether stone objects are of human or natural origin is elemental and constitutes a threshold all analysts must cross before further specialized study is possible. Therefore, the significance of entire sites (and resulting chronological periods based on them) rests not only on the fact that the stone objects encountered in those places are of human origin, but also on our knowledge of precisely how those lithic materials were modified by human hands (Odell 2003).

Qualities of rock important to chipped stone toolmakers are brittleness, fine granularity, and isotropism (Odell 2003). Although the process of fracture propagation that underlies flaked stone artifact manufacture is quite complex, it is nonetheless well understood through the fracture path that determines an object's morphology (Clarkson & O'Connor 2014). The lithic assemblage collected at the study area totals 20 pieces. They are predominantly of quartz. Small fragments of quartz crystals (Figs. 44-45) perhaps of cryptocrystalline silicates, shatter and other small fragments encountered suggest the possibility of microblades. In addition, four larger quartz artifacts in the form of scrapers presenting sharp edges form part of the assemblage (Fig. 45). Although cryptocrystalline silicates, also considered quartz, do not fracture as predictably as natural glasses or obsidians, such silicates can nevertheless be very effective for stone tool production (Andrefsky 2010).



Figs. 44-45. . Microblades, quartz scrapers small flakes and shatter collected at the study area. (Images © Charles Brewer-Carías and José Miguel Pérez-Gómez)

Adornment / Beads.

Most tribal peoples of the past as well as the present are interested in beads. The economic importance of beads was recognized by the Europeans who came into contact with America, Africa and Asia during the Age of Discovery which began in the fifteenth century. Columbus carried Venetian glass beads on his first voyage in 1492 and found them much sought after by the inhabitants of the Caribbean. Trade beads have ever since been a vital part of explorers' stores. In the early seventeenth century, the Dutch East India Company established a bead factory near Amsterdam which turned out products designed for the Indies trade. There is much evidence that the Europeans, when they began to sell or exchange beads in Asia and Africa, were entering a field of commerce which had already existed for millennia (Lamb 1965). Therefore, the presence of beads can signal not only ancient cultures but also ancient trade.

Beads are consumed in large quantities. A single bead necklace may be composed of a hundred or more individual spherules. Such necklaces are often buried with their owners. The material from which beads are generally made, stone and glass, is virtually indestructible. Beads survive when other cultural remains, for example of wood and textile, have long rotted or crumbled to dust. In other words, beads survive fully as well as ceramics. Moreover, while ceramics rarely survive intact, beads generally do. Researching beads incurs a number of methodological problems which no longer confront the study of most categories of ceramics. Exact shades of color, even with the aid of color charts, are often difficult to define. The chemical composition of glass beads is sometimes rather unstable and prone to selective weathering with the result that chemical analysis may vary according to the conditions in which the glass has been buried or submersed (Lamb 1965).

Furthermore, no consensus exists to date on the main headings under which the characteristics of a bead should be classified. For example, some scholars, like van der Sleen, have placed much emphasis on the technique of manufacture. Others, including Horace Beck, have been inclined to prioritize shape and decoration. Clarity does exist, however, concerning the main attributes of a bead. These are: material, color, decoration, shape, method of manufacture, function, purpose, and symbolic value. A single bead was collected at the study site for further analysis (Fig. 46). It appears to be of a crystal nature such as jade or jasper (Lamb 1965).

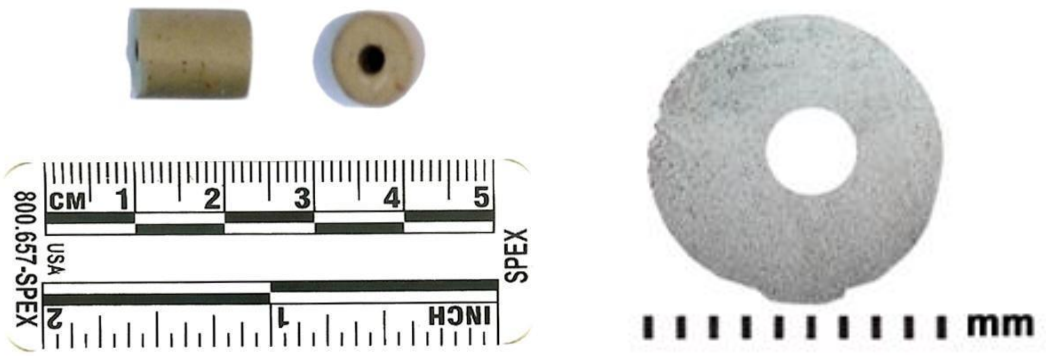


Fig. 46. Bead collected at the study area. Note the bore hole in the thin section prepared for analysis. (Images © Charles Brewer-Carías and José Miguel Pérez-Gómez.)

It measures 15 mm. in length and 8 mm. in width with a bore hole of 2.8 mm. A thin section was prepared for petrographic analysis At the time of writing, it is not clear whether this bead can be associated with the manufacturers of the pottery or if it is the result of trading activities. Further study is indicated to make this determination.

THIS RESEARCH WAS FIRST PRESENTED AT THE: