OLD AQUEDUCTS AND SEWAGE SYSTEMS OF SANTAFÉ DE BOGOTÁ AND HISTORICAL ARCHAEOLOGY OF THE CITY

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To put this presentation in context, Fundación Erigaie (Erigaie Foundation) is a non-profit organization dedicated to cultural heritage research, particularly historical archaeology projects in Colombia. Over the last two decades our research group has developed a Historical Archaeology Program of Bogotá, through which almost 20 buildings (most of them declared as cultural heritage) and 4 major streets have been excavated within the historical center of the city.

Methodologically, this Historical Archaeology Program bases its analysis on archaeological remains, the study of its materiality and printed sources, for which the work depends on a multidisciplinary team. Central in the analysis of these remains and sources is the contrast between them, in order to provide a broader understanding of the archaeological site, its context and the following interpretation of its contents. As the well-known historian Natalie Z. Davis (1987) remarked there is always *fiction in the archives.*

Among the printed sources, besides archival documents and historical chronicles, urban plans, maps, old photos and aerial photography provide valuable information for locating sites or specific excavation units and for a comprehensive understanding of historical and archaeological data and with this the city development. It does not matter if we are excavating on a private house, a building or a public space like a street or a square, this approach from an urban point of view is a key issue as a research tool.

In terms of the archaeological record we take into account constructive events, strata and artifacts, not only in the way they are distributed but also in terms of their changes through time. This stratigraphic method is understood as a time-event relation between strata, following stratigraphic laws: A layer deposited over another tends to be newer than the previous one. However, because what is being studied is a product of human intervention this basic law is not fulfilled, as strata are altered in response of the needs and changes of urban infrastructure (Harris, 1991; Carandini, 1997).

For the Historical Archaeology Program, it is fundamental to understand how these strata were conformed, since they are part of urban infrastructure systems but also result from landfills to raise the floor level, either as a result of deposition processes or intentionally placed.

Within pipes, sewages and landfills, an abundant diversity of artifacts are recovered, such as glass, metals, wood, bones and especially potsherds which constitute the main dating tool since some of the ceramic types have specific production chronologies. Typology is based on their most visible characteristics of paste, temper and style. However, due to the function or other specific characteristics it is mandatory to use chemical, geological or physical methods for the analysis of ceramics.

During the last two years Bogota's 7th Avenue, which until recently maintained its original name of Royal Street, the main street of the colonial city of Santafe de Bogota, has been subjected to an urban renewal project of. Because of its historical and commercial importance as well as the profound impact of the renewal plan, an archaeological project was made obligatory after important remains were uncovered.

The first findings consisted of the rails of the old streetcar system. All at once, as they came as a surprise for contractors and municipal offices, they were expected by some of the older inhabitants since they actually commuted on these cars. In this scenario, the rails interfered completely with the urban renewal designs but as they are still highly regarded by passersby, the archaeological project became a must (Fundación Erigaie, 2015a).

Apart from these remains, the archaeological excavations uncovered an enormous complexity of layers composed by infrastructure, structures and landfills, including several asphalt layers, floors, streetcar rails, sewages and old aqueduct pipelines. The findings evidenced how some intersected others, some were annulled while others are still in use, following different directions and located at different depths. This obviously pressed us to look for patterns, to bring order into chaos. We also raised some basic research questions about use, chronology, and technology of these diverse remains.

And patterns did emerge, at least from the analysis of the hydraulic pipelines that descended from the mountains in an east-west direction, since both waste water and drinking water were installed side by side in the streets in order to avoid or at least minimize water contamination. The reason behind this distribution pattern is pretty simple, but it also explains the city's location: on one hand, the slope of the city determines its foundation between two rivers, as one of the earliest document states:

"What determines the foundation of the city in that place were the facilities that a sanely inhabited city must have, because the ground has the needed height for the waters to run without swamping the streets and squares" (Fray Pedro Simon, 1953[1615]).

A must in permanent cities, is the need to ensure water flow, particularly sewages, so topography has been a core element as can be verified in the case of the founding of Santafe de Bogota, in the 16th century. The same can be said of the location of public water fountains, which depended on the slopes to conduct water by gravity. These hypotheses have been supported by archaeological evidence and contradict conventional historical studies.

The mapping of all the archaeological water pipelines, also allows us to propose that a major number of them correspond to the supply of private houses and buildings, and very few to public fountains. From written sources, and as has been evidenced in a few pipelines, the service was intermittent due to their clogging during heavy rains. These two situations, few public fountains and their recurrent failure, motivated many complains from the inhabitants and reveal the financial and technical problems that the local authorities had to face during the colonial period and most of the 19th century, under the new republican State.

As a result, most inhabitants had to face the problem of transporting water to their own homes, despite the rugged topography of the city and all the inconveniences this involved. The wealthiest used horses or indigenous labor force for this task; the majority had to carry on the water on their backs. The archaeological record indicates that a pre-Hispanic ceramic type in particular (Guatavita Desgrasante Tiesto in Broadbent, 1986) evolved in the city to serve many different new functions (Ome, 2006; Therrien et a., 2002), being one of them as jars for water transportation, storage and service. In the early period, these jars were distinguished by a new decorative motif that included a pomegranate (alluding to the name of the colonial territory of New Kingdom of Granada [pomegranate]), an innovation introduced by indigenous potters to satisfy Spaniards needs, tastes and esthetics (Therrien, 2016). It also meant that not all Spaniards were able to afford their own private aqueducts. Within those that could and had to afford private water pipelines, were the religious orders (Jesuits, Franciscans and Dominicans), as the required to supply their churches and cloisters.

Regarding the technology involved in the production and installation of these pipelines, it has also been evidenced that the Roman technology was followed, by using what Spaniards named *Atanores* or *Arcaduces*. These consisted of ceramic pipe sections assembled by fitting one in the other, and protected by carved rocks, bricks and tiles or a combination of any of them,.

The installation of the pipes and the maintenance of the network were very expensive due to the rigidity of the ceramic, the ground movements and the frequent contamination of water. However, as was evidenced in the pipelines of the Franciscan order and the Jesuits *Collegium Maximus*, we found two or even three different pipelines, installed one over the earlier line, demonstrating continuity of its use and replacement through time (Fundación Erigaie, 2015b).

As for the public pipelines, these frequently broke down and with great delay were repaired, as can be evidenced in the archaeological record and in several archival

documents that reveal these same problems between the 17th and 19th centuries. The use and maintenance of this pipeline technology, also seems to have led to a flourishing trade, for its production, installation and maintenance.

These problems and their costs, are assumed as the causes that lead local plumbers to repair the pipelines with almost anything available, from bits of roof tiles and potsherds to different ceramic pipes reused from older aqueducts. It was also common to adapt different pipe sizes and shapes for these reparations (Fundación Erigaie, 2016). The diversity of forms, finishes, couplings and a diversity of materials required a closer and deeper analysis into the objects involved in this hydraulic system and how they changed from the 16th century through to the beginnings of the 20th century.

In order to answer the most obvious and basic questions about the ceramic pipes and their evolution through time, such as when they were made, where and how, we focused on an archaeometric scope by analyzing shapes, pastes and surface finishes as well as joint materials. Basic measurements like length, diameters, and edges were taken into account, leading to a preliminary classification in correlation to their position in the archaeological stratigraphy and all other artifacts, providing valuable data for an initial dating.

The mineralogical study of ceramic pastes provides important technological information for dating, as well as a general idea about local or foreign sources of raw materials and the whole production process. The results made possible the differentiation of local workshops and the introduction and refinement of burning technologies (such as high temperature kilns above 1000°C) introduced in Colombia on the second half of the 19th century (Therrien et al., 2002). Burning technologies from indigenous tradition or kilns in the earlier periods, provided temperature peaks of over 900°C in some cases but a dominant burning temperature of 800°C approximately.

The presence of certain tempers added to the clay provides information about the origin of these pipes, for the local pipes these consisted of charcoal and/or *chamote* (recycled pottersherds or brick grains) in contrast with earlier European ceramics that used kaolinitic clays with sands and feldspars tempers.

As for the surface finishing technics, it also provides information for establishing chronology and origin by comparing the materials, and the way they were used to obtain a suitable inner surface for water flow. “Standards” and the idea of regularity and product quality, which we have naturalized as a common trait did not exist before the 19th and even 20th century in Bogotá.

A few of the archaeological pipes have homogenous lead-based glazes on the inner surface, similar to those used as decoration on several locally produced and imported colonial pottery types. The SEM-EDS shows a prominent curve corresponding to lead

oxide, as well as other basic elements that are regular glass components. On the other hand, ferric oxide gives the characteristic faint yellow color of the glazes used.

In other samples obtained, it was made evident that during the burning of ceramic bisques under low controlled kiln conditions, smoke and ashes from the wood used as fuel, accumulated over the surface of the pipes producing a kind of vitreous layer mainly composed by potassium carbonate and calcium oxide. As a decorative technique, ash glaze was developed first in China around 15000 BC, but in Bogota it was a mere accident showing a lack of control in the local production.

Local manufacturers also used clay slips, also known as *engobes,* to improve the surface characteristics producing a smooth inner layer. In these cases, the slips are present on both surfaces and a second low temperature burn aided in fixing them. These slips as a decorative technique were broadly used by many pre-Hispanic native communities all over the country.

From written sources it was possible to obtain some formulas used for preparing hydraulic and waterproof mortars, referenced as *Zulaques*, used as joint materials for the pipelines and their repair. Archaeometric analysis demonstrated the use of grounded glass, resins, wood, bones and ashes as part of the composition and additives of these mortars.

The sum of all these results has lead us to a better understanding of the evolution of the hydraulic technology, particularly the aqueduct system, and its adaptation to the conditions of a city like Bogota. This has also provided a first attempt of a general chronology of its pipes, and maybe for the first time, an opportunity to use them as cross-dating markers for buildings and public spaces in the city.

This is however an initial step which must be confronted with every new archaeological evidence. At least we have a time-frame that may be refined with each new project. Also these analyses have been of interest for engineers and architects, and as contractors have prevented them to demolish or mistake colonial aqueducts with the more modern stoneware pipes (modern at least for Bogota). There is a new historical value for these objects even if these results from an urban point of view are quite controversial as will be seen below.

Drainage and sewage system of the city followed the emergence of Hygiene policies and practices introduced by the Bourbon crown in the 18th century. Since a colonial intention to improve Bogota's sanitary conditions, referred in many archival documents, it was only until the second half of the 19th century that a public sewage was properly installed.

Indeed only around 1900 the first sanitary porcelain fabric was open in the city producing the first flushing toilets near 1908 (Peña, 2010). Before that, inhabitants used basins for their sanitary requirements, and according to the documents, throwing out all of its contents into the streets.

As a consequence drainage and sewage structures found among the archaeological record, present a broad range of vault shapes and flow volumes as an evolution of the city's needs and its growth. The public network of sewages was installed around the 19th century, while earlier structures were stratigraphically related to private buildings such as the Jesuit's school.

In order to understand and organized these sewages and their changes through time, archaeometric methods provide valuable information, particularly for the material characterization of bricks and the use of different mortars.

Local brick's fabricants during the second half of the 19th century worked as entrepreneurs, representing international enterprises as "Clayton & Co." or "Wilson", which sold their patented extrusion machines, presumably all over to world, to locally produce uniform pieces but using available materials and technologies. These two brands in particular got into a legal copyright dispute of their patents providing a mark-based chronology for the branded bricks.

In addition classification of sewage bricks lead us to recognize shapes, measures and production processes, using petrographic sections for the mineralogical characterization, in order to identify unmarked bricks complimenting the history about the use of this material in the city (Cardenas & Pulgarin, 2011).

The study of mortars was also a key issue for the understanding of these structures because during the 18th, 19th and 20th centuries, many different materials were used as a result of the economic changes and available technologies. During the Bourbon period of Spanish Crown, lime mortars with river rounded sand seemed to be common while during the 19th century, mainly because of the economic crisis due to the independence and republican wars, lime got almost lost and the mortars started using yellow rock sand as granular portion as well as wood, earth and clays. Also, after 1905 the use of Portland cement emerges, first as part of lime-cement mortars and then completely replacing lime, as a new and harder, cheaper and easy-to use material for the building of these sewages.

All these material innovations, as well as the installation of the whole sewage system for the city, and the further introduction of stoneware or iron-based pipes, are the result of new hopes and "modern" ideals among inhabitants and the public attempt of city's authorities to fulfill people's expectations in terms of public services.

Only an attempt because many of the renewal plans of the end of the 19th century were unable to applied, or were slowly implemented as the economic conditions of Bogota were improving. Scarce financial resources was not the only reason for the unhurriedly development, but the precarious government organization and the lack of an urban planning department.

As a consequence each major, more or less as the same way as colonial government did, decided to contract or import different system not entirely compatible between them and specially not easy adjustable to the existing aqueducts and sewages. Iron pipes from USA, Germany, Belgium and UK were installed on a first moment, and then partially replaced by locally made Stoneware pipes, co-existing with old 18th century brick-mortar sewages, some of them still in use.

This elaborated palimpsest of water management structures, regardless the archaeological importance of these objects as material evidence of the evolution of the city, is showing the recurrence of a series of practices and mindsets that remain the same over time, and that have shaped the current Bogota with its successes and its problems, revealing the reasoning beneath public administration for over 400 years.

Segregation and economic stratification of population continue even today, and since colonial times only rich people could afford water into their homes, while the poorest ones have to deal with the fountains on public spaces and its malfunction. The change of technologies from ceramic "Atanores" to Stoneware pipes was unfortunately not followed by a transformation of the government forms and institutions of the city as well, and today water supplies remain as an unsatisfied need for some inhabitants in Bogota.

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