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Evidence of prehispanic land use and residential areas from the Central Group, South Group and peripheral areas of Tak'alik Ab'aj, based on geochemical and loss on ignition (LOI) studies

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Abstract:
The Investigaciones Geoarqueológicas en Tak'alik Ab'aj project (realized in cooperation between the Tak'alik Ab'aj National Archaeological Park and the University of Warsaw) have carried out the geochemical studies of sediments from excavations and auger sondages within the Central Group, South Group and peripheral area. The aim of the study is to reconstruct the form of land use and determine the function of these areas, as well as to identify the location of residential units. For this purpose, an analysis of the content of soil organic matter by the Loss-on-ignition (LOI) method and the geochemical study of soil for phosphates and other elements (*Strontium, Calcium*) from various locations was carried out.
The study of the strata carried out in the peripheral areas showed higher and more varied values of loss-on-ignition (LOI) than those in the central area. This data, among other geoarchaeological results, seems to corroborate the first hypotheses coming from the traditional excavations.

Keywords: South Coast, Tak'alik Ab'aj, Geoarchaeology, Loss-on-ignition, Agriculture, Phosphate analysis.

Abstracto
En el marco del proyecto de cooperación de Investigaciones Geoarqueológicas en Tak'alik Ab'aj entre el Parque Arqueológico Nacional Tak'alik Ab'aj y la Universidad de Varsovia, se llevaron a cabo estudios geoquímicos de los sedimentos de sondeos y perforaciones de excavación dentro del Grupo Central, Grupo Sur y áreas periféricas. El objetivo del estudio es reconstruir la forma del uso de la tierra y determinar la función de estas zonas, así como identificar la ubicación de unidades residenciales. Para ello se realizó un análisis del contenido de materia orgánica por el método de la pérdida por combustión Loss-on-ignition (LOI) y el estudio geoquímico de suelo en diferentes ubicaciones.
En el estudio de los estratos llevado a cabo en las zonas periféricas se registraron los valores más altos y

más variados de la pérdida por combustión que los de la zona central. Este dato, entre otros resultados geoarquelógicos, corrobora las primeras hipótesis provenientes de las excavaciones tradicionales.

Palabras clave: Costa Sur, Tak'alik Ab'aj, Geoarquelogía, Loss-on-ignition, Agricultura, Análisis de fosfatos.

Introduction

While Tak'alik Ab'aj is known for its Central Group, with prominent examples of pre-Columbian monumental architecture, however outside of this group and the other West, North, and South architectural groups, archaeological investigations uncover many other areas that have less superficial visibility of archaeological remains, but contain archaeological stratigraphies with cultural material and other evidence of human activity in the pre-Hispanic period.

Since 2013, the *Programa permanente de investigación arqueológica con excavaciones de sondeo sistemáticas de patrón de asentamiento y zonas de cultivo en la periferia del Grupo Central y Grupo Sur del Sitio Arqueológico Tak'alik Ab'aj* [*Permanent Archaeological Research Program with systematic test-pit excavations of settlement pattern and cultivation zones on the periphery of the Central Group and South Group of the Tak'alik Ab'aj Archaeological Site*] is studying the mentioned areas and research on the peripheral zone as has been presented in various previous publication, noting housing areas in the western and southern vicinity of the Central Group, while further south of the same group there were large areas proposed as cultivation (Espigares and Medina 2019, Espigares *et al*. 2019, Medina 2019). In this paper the authors present preliminary results of additional geoarchaeological studies conducted in the Central Group, South Group and peripheral areas, and compare them with information from previous research. The paper is based on translation of 2021 article originally published in the conference materials of XXXIV Simposio de Investigaciones Arqueológicas en Guatemala, 2021 Simposio de Investigaciones (Gilewski et al 2022). We publish this paper to present the study revised and in English language via open access platform of the journal Estudios Latinoamericanos.

Residential areas of the Southern Maya region

The Southern Maya region, as defined by Sharer and Traxler (2006), includes the Pacific Coast of Guatemala (and neighboring areas of Chiapas and El Salvador) as well as the Maya Highlands, regions deeply interconnected through culture and geography (Figure 1). Recent archaeological interest in the Southern Maya region has led to the introduction of terms like the "Southern Maya Zone" and the "Southern Corridor of Interaction" (e.g., Love 2007; Love and Kaplan 2011) to emphasize its unique coastal dynamics and multi-ethnic interactions. These frameworks highlight the Pacific Coast of Guatemala as a cultural hub, particularly during the Middle and Late Preclassic periods. Traditionally, the term "Highland Maya" has been associated with late pre-Hispanic K'iche' and Kaqchikel populations in Guatemala and Chiapas, following Sanders and Price's (1968) division of Highland and Lowland Mesoamerica. Meanwhile, an increasing number of archaeological projects have focused on sites located at lower altitudes in the Piedmont and Pacific Coast regions, which have drawn attention for their significant cultural developments during the Preclassic period (Love 2007; Love and Kaplan 2011; Chinchilla 2021). These investigations have shed light on inter-regional connections in the Southern Maya region, with shared cultural traits—such as funerary practices (Ichikawa and Morita 2010), ceramics (Popenoe de Hatch 2019; Inomata et al. 2014), and exchange systems (Schieber and Corzo 2022)—revealing deep-rooted links between Highland and Pacific Coast cultures.

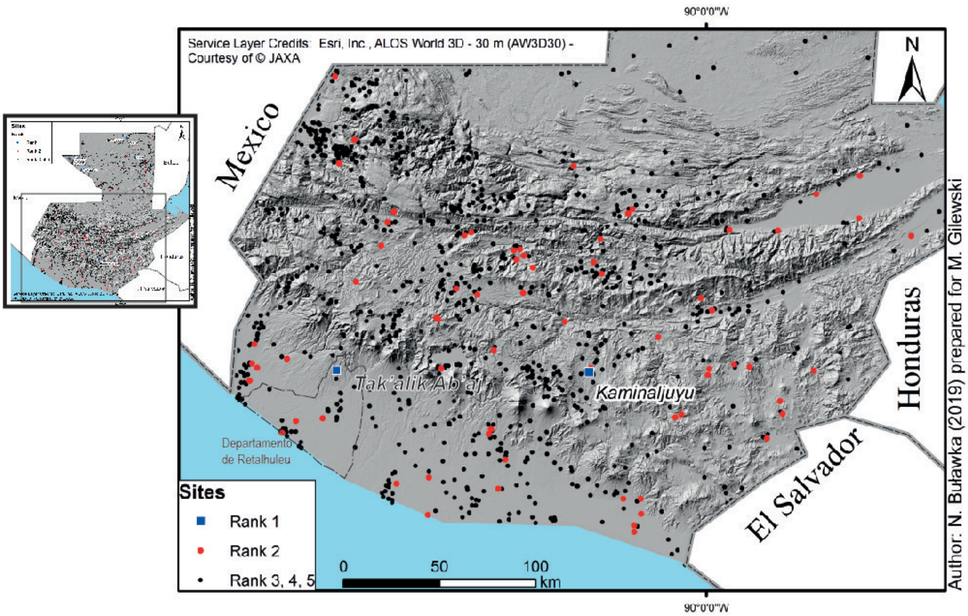

Figure 1. Archaeological sites in Southern Guatemala. Data source, Maya GIS project.

While many studies have focused on the early stages of complex societies and sculptural developments along the Pacific Coast, as well as conducting regional surveys (Love 1989; Chinchilla 1996; Pye 1992), settlement archaeology in this region remains less studied compared to the so-called Lowland Maya on the other side of the Guatemalan mountains. As Chinchilla (1996: 288) observes, the challenges of studying pre-Hispanic settlements in the Bocacosta stem from natural processes such as volcanism and soil formation caused by erosion of ancient clay constructions, sediment deposition, and vegetation decomposition. Despite these challenges, archaeological investigations have uncovered evidence of residential areas at sites like Tak'alik Ab'aj and other contemporary settlements culturally connected to the Bocacosta region (e.g., Arroyo 2004; Chinchilla 2021). Nevertheless, the overall settlement patterns remain only vaguely understood.

Barbara Arroyo (2004) reviewed investigations into residential architecture along the Prehispanic Guatemalan Pacific Coast. During the Middle Preclassic period, residential structures were notably dispersed, located at the distances ranging from several hundred meters to a kilometer from groupings of mounds. A prominent example of such settlement patterns comes from Joseph Michels' (1979) and Marion Popenoe Hatch's (1997) research at Kaminaljuyu, which revealed residential areas—some featuring hearths and intensive irrigated agricultural fields—strategically situated between the site's six clusters of mounds.

Evidence of residential architecture includes rectilinear stone alignments, which may have been used to protect and separate walls from soil moisture, drawing parallels with ethnographic examples (Arroyo 2004). However, the use of stone appears more prevalent in Late Classic contexts. In contrast, Preclassic houses were likely constructed almost entirely from perishable materials, featuring rammed earth or clay floors and wattle-and-daub (*bajareque*) walls, or possibly walls made of cane and wood. Notably, excavations often fail to reveal postholes in such structures (Arroyo 2004).

Recent investigations of household remains at the site of Izapa in Mexico (approximately 70 km to the west from Tak'alik Ab'aj) by Rebecca Mendelson (2019:249, 258) uncovered bajareque fragments with traces of white plaster, suggesting that some households may have employed plastered walls. In the neighboring Soconusco region of Mexico, studies led by Barbara Voorhees focused on Postclassic and Colonial period settlements. These studies show that indigenous construction techniques often incorporated thatch, poles, and rectilinear cobble foundations, with the quality and durability of wood playing a significant role in household longevity (Moore and Gasco 1990). Residential areas in this region are sometimes identified through test pits revealing household ceramics or cobble piles left from demolished structures (Moore and Gasco 1990; Voorhees and Gasco 2004:5).

The absence of platforms makes identifying Pacific Coast residential remains particularly challenging. Arroyo compares these remains to "invisible households," akin to ground-level perishable structures documented in the Preclassic Petén (Johnson 1993) and Yucatán (Ringle and Wyllys 1988). In West Central El Salvador, the exceptional preservation at the site of Joya de Cerén, discovered accidentally, provides an unparalleled glimpse into ancient residential architecture and daily life.

The Joya de Cerén, preserved by volcanic ash in the Zapotitán Valley, offers a "Pompeii-premise" preservation of households, tools, and agricultural fields, providing exceptional insights into daily life and spatial organization. While the archaeological site may remain geographically and culturally distinct from the Guatemalan Pacific Coast at the time of the (see Neff et al. 1999 for overview of history of potential direct relationship of South Guatemala and Pacific Coast upon ceramic studies), it is likely that it provides provide rare glimpse into household plans and activities typical to this part of Mesoamerica in general. This site reveals a complex spatial arrangement of house compounds, courtyards or patios, gardens, agricultural fields, and middens (see Sheets 2002). Despite its unique preservation, Payson Sheets had cautioned against isolating Joya de Cerén as incomparable, noting its value for comparative studies with less well-preserved sites. The spatial arrangement of house compounds and form of courtyard/patio and garden is related with broadly Mesoamerican household idea called houselet (see Figure 2), which also has to be understood with some agricultural areas located next to the houses (so called infield) in opposition fields at distance to the household (so called outfield). Also the household compound illustrated the inventories presenting quantitative/contextual information about use vernacular architecture, and ceramic and groundstone artifacts f.E. suggesting that each household had a set of metates and doughnut circular stones, which in one context was found as weight for digging implement (Sheets 2002).

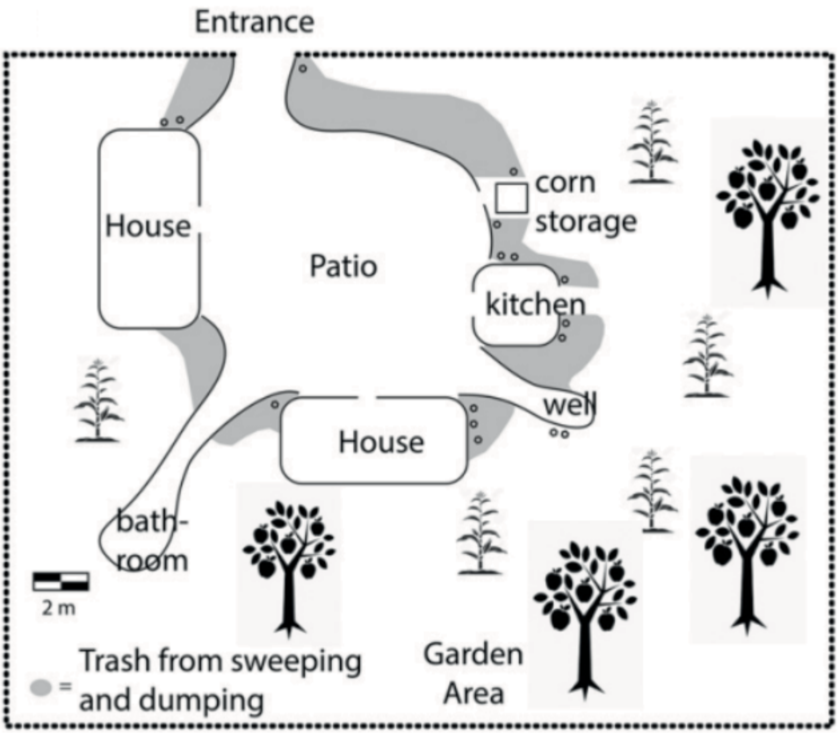

Figure 2. Maya houselet model, courtesy of Scott Hutson.

In Pacific Guatemala, preservation conditions are far more challenging, and evidence remains limited. Excavations at La Blanca and El Ujuxte, for example, highlight differences in ceramic types and storage practices. At El Ujuxte, households included large storage facilities and evidence of dog husbandry. Meanwhile, excavations at Flamenco near Retalhuleu uncovered some possibly both common and elite households judging on size, with spindle whorls suggesting textile (Arroyo 2004). Ritual activity remains poorly understood, though some evidence, such as concha figurines from La Blanca and La Victoria, points to its presence. Human burials beneath house floors occasionally include jade artifacts, as seen at Balberta (Arroyo 2004). Overall, as Arroyo's review of Pacific Coast research the archaeological research presents the limited scope of excavations and the fragmentary nature of the evidence of residential.

The residential areas in Tak'alik Ab'aj and it's land use pattern

In Tak'alik Ab'aj, the spatial organization of monumental architecture and the local landscape suggests the presence of integrated areas, called here peripheral zones, used for settlement beyond the groups of monumental architecture. This research aims to explore the functions of those areas peripheral and how ancient populations utilized these spaces—shedding light on their daily lives and activities.

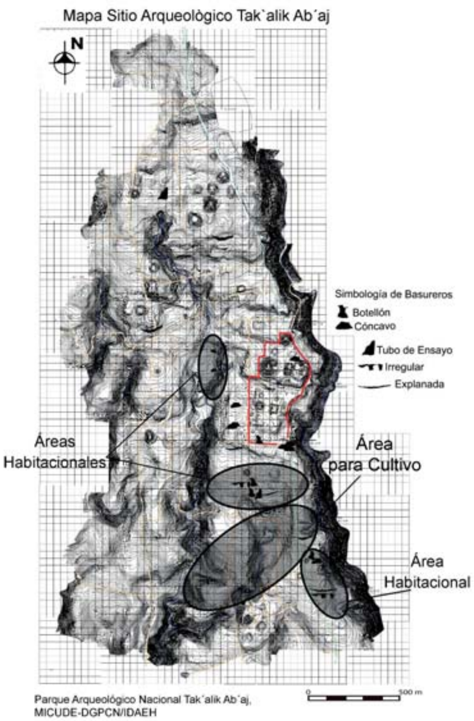

Figure 3. Topographic map of Tak'alik Ab'aj. The red line denotes current border of the archaeological parque (and the Central Group).

Number of PANTA investigations have documented archaeological contexts identifiable with household remains, residential area activities. While such context were limited in findings, those test-pits in the areas show continuous presence of ceramics, show that the majority of areas between and next to mound groups were inhabited or at use. Not all the areas surrounding the site were yet surveyed – the best studied areas at the time of the study were the peripheral zones West and South of Central Group (Figure 3). It is also possible that site extends out of currently known areas.

Excavations at the El Chorro stream, approximately 160 meters west of the Central Group, revealed a house with a couble stone floor, a wooden framework (some with interlocking notches, Miguel Orrego Corzo, personal communication), posts, and a *zacatón* (palm) roof (Figure 4). This structure was adjacent to a stone channel. Remarkably, the preservation of domestic remains, particularly plant materials, in this sector is attributed to flooding event at the end of the Middle Preclassic period (800–100 BC), evidenced by a layer of gray soil in the stratigraphy (Schieber de Lavarreda et al. 2019). Pollen studies (Popenoe de Hatch and Leyden 2004) indicate that this sector was associated with the cultivation of maize (*Zea, Poaceae*) and sweet potato (*Ipomoea batatas, Convolvulaceae*) during the site's earliest phase (Ixchiya, 800–500 BC). This preservation contrasts with the limited evidence from other residential areas outside this sector (Schieber de Lavarreda and Orrego Corzo 2001:9; Schieber de Lavarreda and Claudio 2004:411–412).

Figure 4. Archaeological drawing presenting possible reconstruction of the household near the El Chorro stream

The limited evidence about household context in other areas is substantiated by archaeological finds documenting economic activities and occupations. To the east of the El Chorro stream lies La Casa Río Blanco, occupied during the Nil 1 (500–350 BC) and Nil 2 (350–100 BC) phases. On its later floor, fragments of obsidian debitage from prismatic knife production were uncovered (Crasborn 2007:9; 2014:84; Schieber de Lavarreda 2007:3). Various plant species were also identified in this area (Schieber de Lavarreda and Claudio 2004:405; Mauricio Tipaz †, personal communication, 2001–2007).

During the Late Preclassic period (100 BC–150 AD), the "El Escondite" canal system was constructed north of the El Chorro stream apparently to supply drinking water to La Casa El Escondite and La Casa Grande Riachuelo El Chorro.

These structures featured cobbled floors and were built on modified natural rock, with the latter structure associated with two plain stelae (Schieber de Lavarreda 1997a:3; 1997b:1, 6; 1999:42). A midden at the foot of Terrace 1, southwest of the Central Group and dated to the Ruth phase (50–150 AD), contained abundant cultural material, including fired pits and stone carving debris (Medina 2014:22–27). Southeast of the Central Group, the "Deposit of the Clay Beads," an Early Classic (150–500 AD) garbage midden, yielded obsidian, lithic, and ceramic material, notably thirty-nine clay beads interpreted as possible fishing net weights (Espigares 2016). Nearby, the Late Classic "House of the Boxer" (500–900 AD) was discovered, named after the elaborately shaped "Puno de Piedra," a knuckle-duster-like stone artifact (Espigares 2017). Recent additions include the "Casa del Hilandero" in the

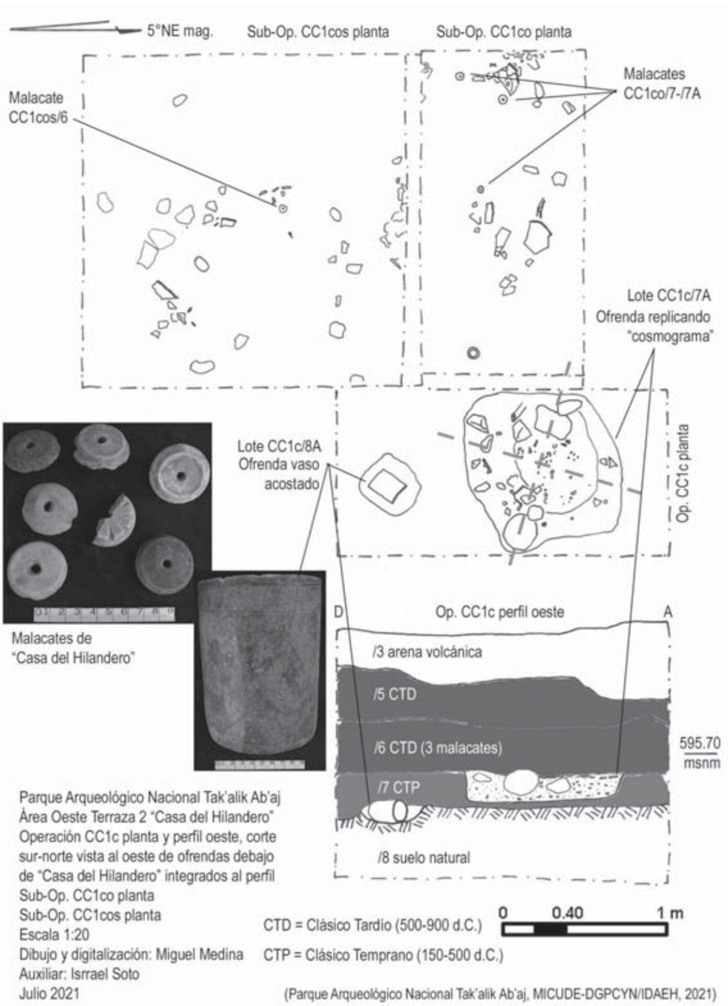

Figure 5 Offerings in layers beneath the "Casa Hilandero".

"West Area Terrace 2," located approximately 120 meters south of the CC4a garbage midden. This site, named for the discovery of seven spindle whorls, has preliminary dates ranging from the Early Classic (150–500 AD) to the Late Classic (500–900 AD).

Beneath the "Casa del Hilandero", two offering deposits were found in pits. One represents a "cosmogram" (Schieber de Lavarreda 2016; Schieber de Lavarreda et al. 2018), while the other appears to be a foundational offering, featuring a cylindrical vessel lying on its side (Figure 8). Recently, remains of ritual activities were discovered about 80 meters north of the Operations' CC4a midden, with containing reddish fired pit, pots, obsidian fragments, a stone, and charcoal. These findings suggest that ritual life was not limited to the ceremonial core but extended into the peripheral residential zones, mirroring smaller-scale ceremonial activities observed in the Central Group (Espigares 2015b; Schieber de Lavarreda et al. 2018; Schieber de Lavarreda and Claudio 2005).

Figure 6. Hacha Rivera

The relatively "empty" areas south of the Central Group, with minimal structures, monuments, or cultural materials, have been proposed as agricultural zones. Flotation analysis has identified Poaceae seeds, including one resembling maize (Zea) (Espigares 2015a, 2016; Hernández 2016). A noteworthy find is the "Hacha Rivera," a well-crafted stone axe with a curved, beveled adze-like shape, suggesting it was mounted on a wooden handle for agricultural use (Schieber de Lavarreda and Claudio 2010).

Methods of work

In this work, a geochemical analysis was applied, as another line of research for the study of ancient settlements. It relates to two basic components of soil chemistry that are of fundamental use in archaeology: phosphate and soil organic matter or soil organic carbon, as they are related to human activities and "adhere" to the topsoil (Holliday 2004). Soil organic matter (MOS) is known to increase due to human activity (such as manure or garbage middens, anthropogenic stimulation of vegetation growth) used to help define site boundaries, occupational zones, and site activity area (Holliday 2004:298-300). Some studies indicate that MOS levels can be modified by the agricultural context (Holliday 2004:298-300, Alcántara *et al.* 2017). In the Maya region, several studies used stable carbon isotope analysis of soil organic matter to identify evidence of maize agriculture (example: Burnett *et al.* 2012). In this study, samples were analyzed using the Loss-on-ignition (LOI) method to quantify the amounts of MOS in cultural strata. Loss-on-ignition studies in Central America include some of human activity (Fulton *et al.* 2013) and archaeological profiles (Robinson *et al.* 2002). Soil organic matter may undergo a process of decomposition in some context (Holliday 2004:298-300). This project will test whether measuring organic matter content can provide any observations on differentiation in relation to spatial distribution and thus provide inferred information about the spatial diversity of the Tak'alik Ab'aj site in relation to function, and possibly agriculture and vegetation.

In terms of geochemical research of phosphates, there were several phosphate prospecting studies that were carried out in the Maya region (see, for example, Ixtutz - Jacobo 1993, Ramonal and Tikal - Burnett *et al.* 2012). The present research uses phosphate and other elements studies in a survey in the area where midden and concentrations of artifacts were located in Operation CC4a located west of Terrace 2 of the Central Group, to map the potential differentiation of the phosphate and other elements levels that would be related to human activities (Figure 1). Samples for LOI analysis were obtained from stratigraphies of 3 excavation units and 10 auger prospecting locations during field season 2019 (Figure 6). In 2022 field season additional samples were retrieved from additional peripheral areas, but the laboratory research is still in process. In the excavated units, samples were taken from the excavation profiles at fixed vertical intervals: 12 cm in Operation G8pe located in Structure 7, 14 cm in Operation F7s located in Structure 89 and interval of 16 cm in Operation A-31h located in the South Group. In the bucket auger sampling, samples were taken from each new archaeological stratum. The sampling locations were drilled using stainless steel Eijkelkamp hand probes with 7 cm diameter augers suitable for clay and mixed soils. Samples were taken during the drilling process and excavated profiles. The material was collected in such a way as to ensure that the sample is not contaminated (from inside the bucket load and below the surface of the profile) using clean equipment (Eijkelkamp knives). The geochemical samples were sent to Bureau Veritas Minerals' laboratory in Guatemala City. The samples were processed by the company's standard preparation and by ICP-ES analysis of acid digestion. 109 samples for combustion loss were sent to the selected analytical laboratory. The sample was dried and crushed in a mortar. The samples were analyzed in the laboratory of the Faculty of Earth Sciences at the University of Toruń with the cooperation of Dr. Barbara Woronko. The organic matter content is based on combustion loss at a temperature of 550 degrees Celsius for 4 hours.

Peripheral Areas and Central Group – Results of analysis of archaeologi-

cal material and LOI

Due to the aforementioned problems with the visibility of archaeological features in peripheral areas, and due to the fact that the recording of residential contexts until recently was limited in the peripheral some areas, it is very appropriate to discuss the indirect archaeological or geoarchaeological evidence to recognize different function of the functions of peripheral zones. Studies in the Maya region noted that even the household debris can be greatly varied (Hutson and Stanton 2007). In the ceramic study of 2729 materials recovered in the southern and western peripheries (1091 pots = 40%) and in the core area of the site (1638 pots = 60%) differences on the distribution of ceramic types are visible (Figure 7). The Rocrís and Caneca ceramics are utilitarian, Ropóm is a ceramic type that was used for the manufacture of utilitarian and fine ceramics, finally Naranja Glossy and Santiago are fineware ceramics, such usage of more precious objects suggests that the activities of greater importance or "rituals", were carried out within the core area of the site (Figure 7); contrary to the five most representative ceramic types of the periphery Rocrís, Caneca and Canero are utilitarian ceramics, which implies that areas of the peripheries were primarily domestic in character; however, Ropóm and Engobe Naranja (the latter also used for the manufacture of utilitarian and fine ceramics) indicate that ritual activity also took place in the periphery, but to a lesser extent (Figure 7).

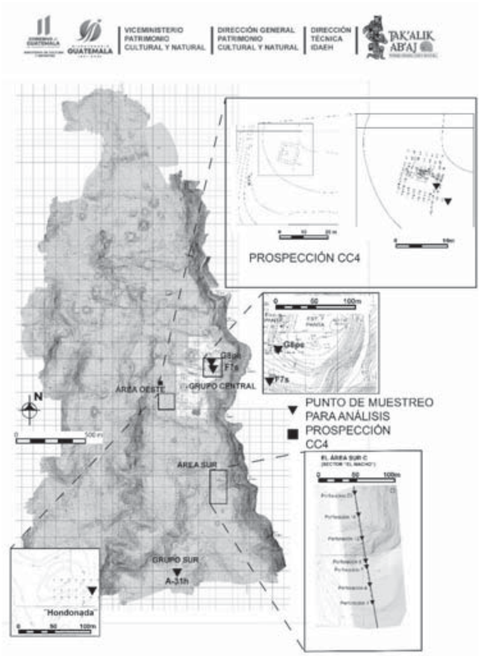

Figure 7. The areas investigated in 2019

An intra-site differentiation is implicit in the distribution of types of lithic and obsidian artifacts. The total sample of lithic pieces recovered from the site comprises 828 items. The sample is integrated by the four categories with the largest number of units, these being grinding stones, manos grinding hand-stones, straighteners and rings. The presence of lithic in the core areas is the most representative with a total of 553 units = 67%, while the periphery is smaller made up of 275 units = 33% (Figure 3a). The Late Classic (500-900 AD) presents the largest number of pieces during all cultural stages of Tak'alik Ab'aj (Figure 3b). The grinding stones and hands predominate with a higher figure than the other categories, this pattern can be observed both in the core areas (grinding stones 272 = 49% and grinding hands 240

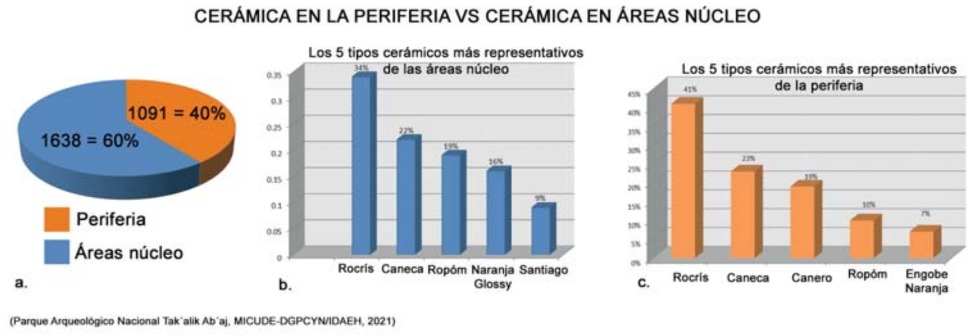

Figure 8. 8a. Pottery from the periphery vs. pottery from core areas. 8b. Most representative pottery from core areas. 8c. Most representative pottery from the periphery. *(Source: National Archaeological Park Tak'alik Ab'aj, MICUDE-DGPCYN/IDAEH, 2021)*

Figure 9. 9a. Presence of lithics in core and peripheral areas. 9b. Lithics by period. 9c. Lithic units documented in core vs. peripheral areas. *(Source: National Archaeological Park Tak'alik Ab'aj, MICUDE-DGPCYN/IDAEH, 2021)*

= 43%), as well as in the periphery (grinding stones 161 = 59% and grinding hands 97 = 35%), reflecting a wide activity to process food within the growing population of Tak'alik Ab'aj (Figure 3c). In the cultural periods the highest sample of stones and grinding hands is observed in the Late Classic (500-900 AD), indicating that there is an increase in food to process and therefore a high number of inhabitants, supporting the hypothesis of the high level of population in the site during this time, and reflecting greater activity in core areas than in the peripheries. The variety of types documented specifically in grinding hands may indicate diversity of ways to produce food (Flores 2016).

Some distinguishable changes in the frequencies of obsidian types between peripheries and core areas have been revealed by the study of 1374 artifacts, of which 1112 = 81% come from core areas, leaving below the peripheries with 262 = 19% (Figure 4a). In both areas the most used source of obsidian was that of El Chayal, the three predominant types of artifacts are prismatic knives, large and small flakes, prismatic knives standing out for their technology (Figure 4b). The most obvious representation of prismatic knives from El Chayal (Figure 4c) can be found in the peripheries for the Late Classic (500-900 AD), in contrast to the core areas where it is most predominant during the Late Preclassic (100 BC-150 AD). (Carlos Espigares, personal communication 2021). In core areas the use of prismatic knives is greater with 575 pieces = 69%, compared to the other two types of artifacts (large flakes 131 = 16%, small flakes 128 = 15%), present in ceremonial and domestic activities. While in the peripheries its use is lower with 142 pieces = 49% in contrast to the other two types of artifacts (large flakes 120 = 42%, small flakes 27 = 9%) suggesting that these areas were intended not so much for activities as those observed in the main groups of Tak'alik Ab'aj.

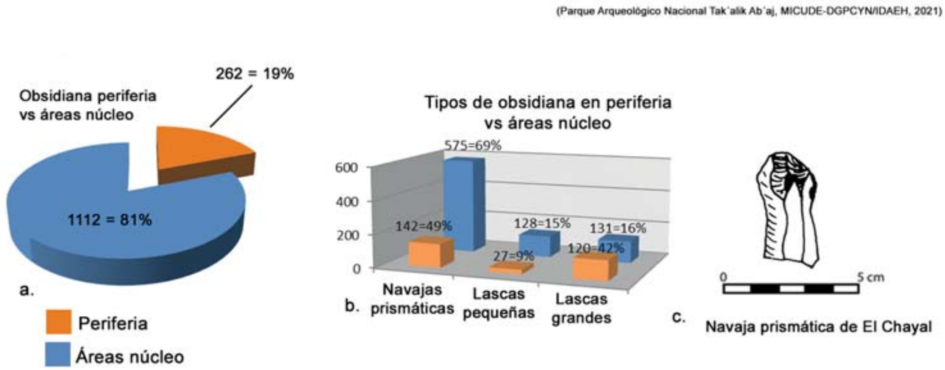

Figure 10. 10a. Graph showing material analyzed in the periphery vs. core areas. 10b. Graph showing the trend of obsidian types in the periphery vs. core areas. 10c. Prismatic blade from El Chayal. *(Source: National Archaeological Park Tak'alik Ab'aj, MICUDE-DGPCYN/IDAEH, 2021)*

Regarding the distribution of the 31 registered middens, 17 = 55% are located in the peripheral areas of which the Botellón (bottle shaped) type stands out (6 garbage middens) during the Early Classic in its Alejos phase (150-300 AD). The remaining 14 garbage middens = 45% were located in the core areas, where the Concave type (5 garbage deposits) is the most frequent recorded from the Late Preclassic (100 BC-150 AD) to the Late Classic (500-900 AD) (Figure 5). The evidence of garbage middens begins in the Middle Preclassic (800-100 BC) with the presence of a botellón garbage midden in the Central Group associated with the Plaza Hundida (Schieber de Lavarreda and Pineda 2006). In the Late Preclassic (100 BC-150 AD) there is increasing evidence of garbage middens with greater diversity of forms. The Early Classic (150-500 AD) and Late Classic (500-900 AD) are the periods where there are more midden, suggesting at the same time, as in the case of grinding stones, an increase in population. In the Early Classic the bottle type predominates and in the Late Classic the five types are represented homogeneously.

Evidence of differentiation is also present in the MOS results, which were

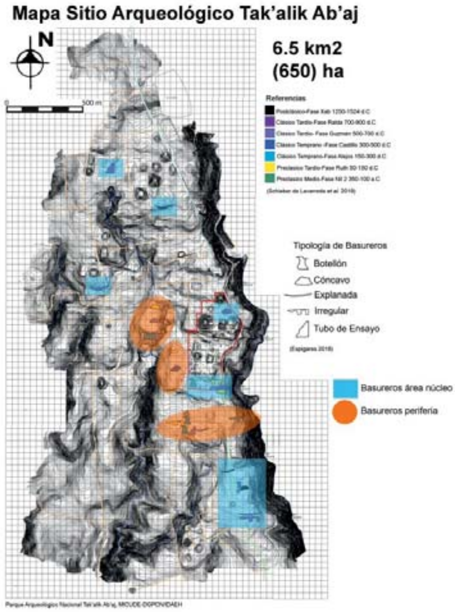

Figure 11 Map showing the distribution of middens in Tak'alik Ab'aj (periphery vs. core areas). (Source: National Archaeological Park Tak'alik Ab'aj, MICUDE-DGPCYN/IDAEH, 2021)

measured in 17 profiles located in the peripheral zones and Central Group areas. Samples were obtained from Operation G8pe, which is an excavation on the west façade of Structure 7, Central Group. A second series of LOI is related to truncation in natural activities and traces of fires. Operation F7s is an excavation that exposes the fills that relate to Structure 89 and the occupation of Terrace 3. The deepest part of the stratigraphy of the profile represents material more related to the natural soil. Operation A-31h presents a fill in a depression near the South Group, where material from the Early Classic (150-500 AD) and Late Classic (500-900 AD) has been recovered.

In addition, LOI samples were obtained from profiles obtained at 10 auger test locations. 3 profiles of LOI were obtained in the West Area (2 of

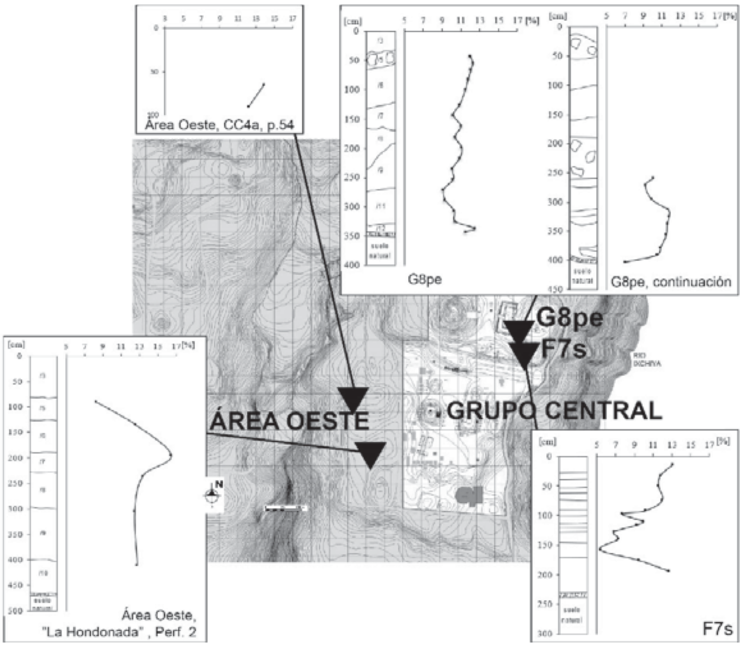

Figure 12 LOI profiles in the Central Group and Western Area.

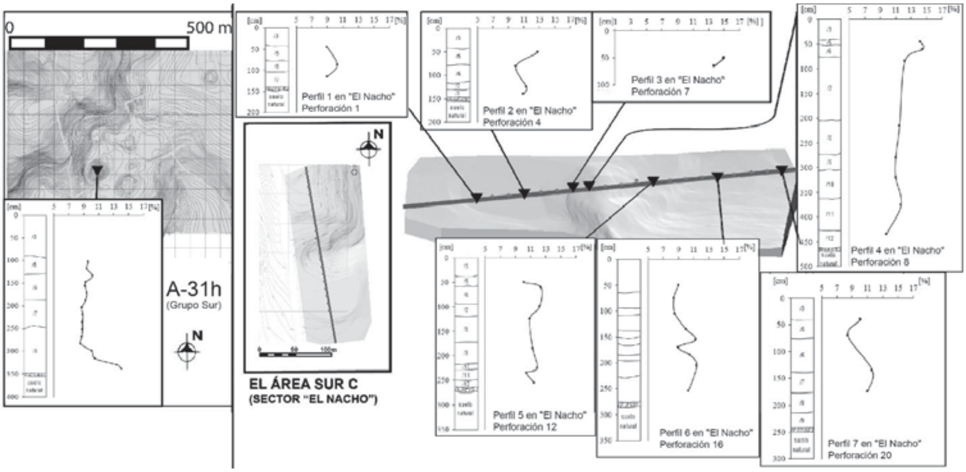

Figure 13 LOI profiles in the Southern Group and South C Area

the CC4 quadrant and 1 in the "Hollow"). 7 LOI profiles were obtained in the "el Nacho" sector, South C Area, in the peripheral zone. In one of the profiles (Perf. 16) radiocarbon date was obtained (lot 9, Wk-51959, 1970 ± 21 BP, 1-120 A.D. [88.8% confidence level] or 40-10 BC [6.6% confidence level]).

Vertical sampling, since profiles contain different layers from various periods, is related to temporal variation. However, samples that are associated with sediments of constructive layer profiles of the Central Area of the site, and samples that are related to the "architectural" stratigraphy of A-31h in South Area are characterized by a very small variation in the percentage of LOI (Figure 6 and Figure 7, see Table 1). The percentage in those samples also appears to be of lower organic matter content in the layers. The samples that are associated with the profiles of the Peripheral Areas of the Central Group (West Area and South Area) are characterized by a greater variation in the percentage result (Figure 7). The percentage in those samples also appears to have higher results (also with higher maximums), suggesting higher organic matter contents in the layers and greater variability of organic content in soils. Some profiles (Profile of "Hondonada" and Profile 4, Sector "el Nacho") have a mixed pattern. In lower part of the stratigraphy little variety of organic material is observed, but the upper layers are characterized by greater variety and quantity of organic material.

Patterns of human activities in the Area West of Central Grup. The geochemical survey near op. CC4a midden

The other goal of this research was to use geochemical analysis to study smaller-scale intra-area habitation patterns and related activities. Recognizing indications of various residential and ritual activities in the "West Area Terrace 2", a geochemical prospecting study was carried out in the vicinity of the test pit

CC4a and its extensions, where a large open midden pit with stones and quantities of cultural material was found in previous excavations and interpreted as related with some possible nearby household (Schieber de Lavarreda 1998). The survey was carried out with 50 samples taken between 40 and 90 cm deep from lot 6 (Figure 9). Sampling points were located on several transect lines in the vicinity of the CC4a midden designated to locate new archaeological features and map human activities. In sample points 17 and 39, two high-precision radiocarbons were obtained in material recovered from lot 7 (p. 17 - Wk-51955, 1912 ± 20 BP 60-210 AD [95.4% confidence level] and p. 39 - Wk-51956, 1953 ± 13 BP, 20-120 AD [95.4% confidence level]).

The sampling procedures with geological probes were carried out with the study of the local stratigraphy up to the natural soil and observations on the recovered material. In the sample group (No. 17, 18, 19, 20, 21, 22, 23, 24, 44) deeper cultural stratigraphy is observed indicating presence of some pit or midden, as with the presence of carbon in soil and large amounts of small pieces of ceramic in the material recovered from the sampled column (Figure 9). In point 18, the cultural layer continues to a depth of 395 cm. In drillings 18, 22 and 24, stones were observed at 190, 263 and 120 cm depth, respectively. All other boreholes recorded the natural soil approximately 1 m deep (99 cm on average).

The results of phosphate samples show diversity of phosphate values (max.: 0.204%, min.: 0.121%, averaging 0.158%, average of 5 lowest: 0.126%) and in horizontal distribution, areas with concentrations of elevated phosphate values are clearly noted (see Figure 9). An example of such an area is found in Sub-operation CC4bees (extension of CC4a) with drilling 17 having the highest phosphate measurement (0.204%), and continuing 3 meters to the south. It appears to be related to the mentioned sample with more cultural material, and probably relates to the context of the cultural material in CC4a and CC4bees.

In the visual inspection of the phosphate level distribution, it appears that in other areas phosphate is also concentrated, as if it were located outside the CC4a midden, and outside the aforementioned concentration areas. Meanwhile, some recent studies (see Halperin and Foias 2016) suggest that phosphate concentrations can be located in areas surrounding residential units, as organic waste is removed from the home.

A similar pattern was observed with other chemical elements, which were visualized using GIS software to produce chemical distribution maps. Strontium, an element closely associated with human biological activity, revealed intriguing similarities and differences when compared to phosphate distributions. For strontium, the distribution pattern slightly differs from that of phosphate in the area. Notably, strontium concentrations were high to the southwest of Operation CC4a (sample points 32 and 31) and to the southeast (around additional sample points), aligning with some of the phosphate concentrations. However, the low strontium

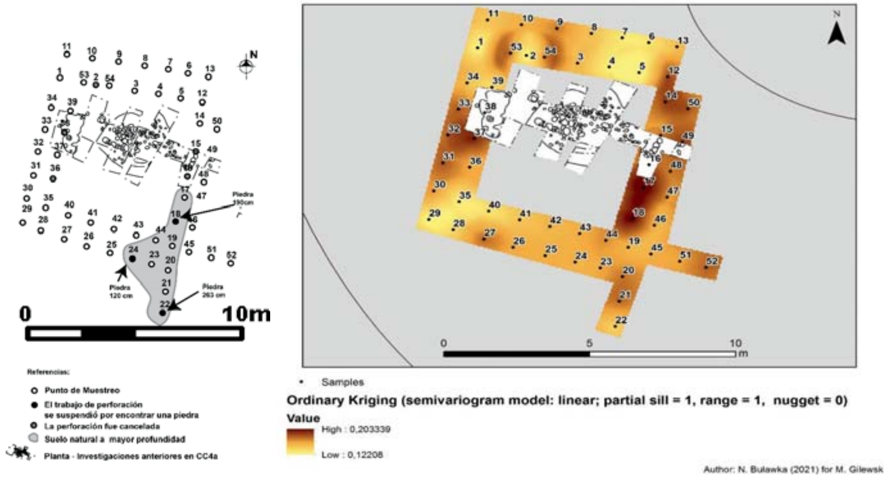

Figure 14 Phosphate prospecting in CC4a.

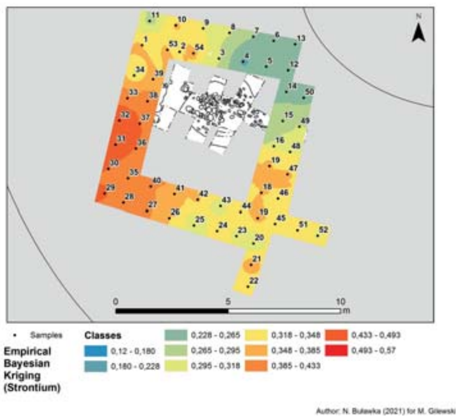

Figure 15 Strontium prospecting in CC4a.

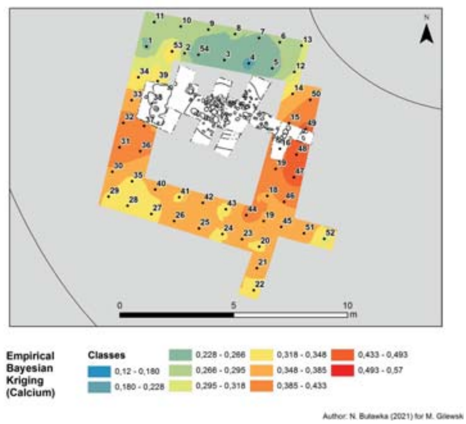

Figure 16 Calcium prospecting in CC4a.

concentration in the northeast part of the surveyed area contrasts with the high phosphate concentrations recorded in the same region (Figure 15).

Calcium, which may be associated with the use of wall plasters or alkaline solutions in food processing, also exhibits a highly ordered pattern of concentrations. This pattern appears to align closely with the distribution of phosphate and strontium, as areas of increased calcium concentration strongly correlate with the elevated levels of these previously mentioned elements (Figure16).

Discussion and interpretation

In the case of the Area of Central Group, in phosphate prospecting near the CC4a midden, the presence of an area of elevated phosphate levels should be interpreted as an area of elevated levels of past human activity, related to that midden or associated household debris. This suggestion is also supported by the material presented by auger prospecting, which recorded a much deeper stratigraphic pattern in the area, with additional layers containing larger amounts of cultural material (Figure 9) and analysis of Calcium and Strontium provide important additional information. The correlation of those elements that should be associated with human activites imply that the area had some spatially specific pattern of human activities. It is known that that geochemical studies showcase that Maya houselet leave a certain spatial geochemical signature, as relating with refuse pattern and the spatial partition of activities. Interestingly such combined geochemical signature indicator of houselet, and perhaps a represent a great potential for future geochemical studies.

While findings from housing contexts have been recorded almost exclusively in the area west of the Central Group, the LOI results for the 109 samples suggest that soil organic matter allows discussion of a number of observations that may explain various functions of the Central Group and Peripheral Zones in general. Despite some limitations related to organic matter and postdepositional processes, some trends can be postulated based on the results of the samples from the excavations in Structure 7 and Structure 89 located on Terrace 3 of the Central Group, which seem to have a series of very similar results in the constructive layers. This suggests that they could have been highly processed materials forming mixtures made to fill constructive layers of earthworks. Such should have been processed this way on purpose, as they appear to contain small amounts of organic material (if this is not solely related to decay), which is perhaps related to the fact that these layers needed stability to support an enormous weight of architectural and landscape modification structures. Despite the fact that these are accumulations of different periods, they seem to have a great uniformity, suggesting that the construction technique changed little.

While it should be recognized that some post-deposition processes can influence MOS levels, in the Tak'alik Ab'aj Central Area there was a trend towards smaller amounts of organic matter in the soil, and perhaps this relates to a smaller amount of vegetation with the central part of the site. The results of the location of the peripheries indicate that here there are greater amounts of MOS (very high LOI values are observed in the Western Area) and fluctuations of soil organic matter. Such changes in profiles suggest that human activities and/or vegetation related to organic matter deposition were changing in peripheral areas, indicating residential or crop use. The mixed pattern observed in the "Hondonada", West Area, suggests that first there was a constructive phase, and the depression was filled and then the area had a very high amount of organic matter and was probably under some important crop.

Conclusion

Geochemical investigations provide information present in the Central Group and the other areas. They suggest that human or biological activities have a different pattern in different areas. Phosphate prospecting in quadrant CC4 presents an area of concentration of phosphate values at the site where auger prospecting confirms the presence of archaeological evidence of domestic remains with cultural material, which is a previously documented garbage midden (Schieber de Lavarreda 1998). The geochemical pattern suggests the presence of a spatially organized household unit, similar to known archaeological and ethnographic houselet units. These typically consist of several houses, a patio or courtyard, refuse patterns, and specific spatial arrangements.

Statistical analysis of the materials recovered from the test pits indicates that these are household debris, pointing to residential activities and a significant presence of the ancient population in the peripheral areas. In addition to artifacts suggesting activities such as weaving, fishing, and tool production, the presence of certain lithic implements further suggests that agriculture was also a key occupation of the inhabitants.

The LOI study suggests a temporally diversified amount of organic matter in anthropogenic soil profiles in locations outside the Central Group. This could be due to changes in vegetation (which are related to deposition or erosion processes) or sources of material, perhaps indicating the presence of controlled and/or changing vegetation introduced anthropogenically in peripheral areas. Due to the rapid growth of the environment the subtropical forest of Tak'alik Ab'aj would be related to a steadily increasing amount of organic matter. Soil organic variability can be interpreted as a result of anthropogenic influence, for example, agricultural and residential use of those areas.

In short, the geoarchaeological project recorded new evidence that reinforces previous models derived from archaeological research on the function of peripheral areas of Tak'alik Ab'aj as residential and cultivation areas.

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