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RESEARCH

Community-Engaged Archaeology with the Tz'utujil Maya to Approach the Submerged Cultural Landscape of Lake Atitlán (Guatemala)

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Abstract
The need to rethink approaches to underwater archaeology from a community-engaged and heritage co-governance perspective has become a major challenge in the territories of contemporary Maya populations in Central America, particularly in the Guatemalan Highlands. This study presents the process that led to a new archaeological assessment in the waters of Lake Atitlán, where various operations were jointly defined and collaboratively conducted with the Tz'utujil Maya community. We then analyze the outcomes of the initiatives undertaken—both underwater and alongside the archaeological diving activities—which confirmed the existence of an exceptional submerged cultural landscape in Lake Atitlán, shaped by past lake-level fluctuations. Finally, we explore the broader implications of this experience for the development of more inclusive heritage management policies—at both regional and international levels—grounded in the recognition of Indigenous ontologies.

Keywords Indigenous ontology · Collective appropriation · Underwater archaeology · Inland waters · Heritage governance

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Introduction

Understanding the nature of underwater cultural heritage—its materiality, characteristics, and meaning—is a key research challenge in order to develop appropriate management policies for the sustainable conservation of submerged archaeological remains. However, alongside the procedures and legal frameworks specific to each country—which govern heritage management, particularly in response to the demands of the scientific community and the ethical principles of archaeology—other equally legitimate needs are emerging, especially within the territories of contemporary Maya populations in Central America.

It is within this context that, in Guatemala—and more specifically along the southern shores of Lake Atitlán—the Tz'utujil Maya community has recently undertaken initiatives related to the governance of its local tangible heritage. This mobilization follows recreational diving activities and underwater archaeological interventions carried out in the lake since the 1990s (Medrano 2011b, p. 93), none of which involved any prior consultation with local communities. It is part of a broader movement of cultural awareness and assertion, calling for the recognition and respect of Indigenous ontologies, not only in relation to community engagement in heritage-related actions, but also in the very principles underpinning heritage policy development.

In this regard, in 2011, the Tz'utujil community—through the voice of its leader *Cabecera* Nicolás Zapalú Toj (1945–2024)—voiced its discontent over recent underwater archaeological interventions in the lake. This claim was acknowledged by national authorities, who prohibited diving at one of the lake's most emblematic archaeological sites through Resolution 169–2013, [1] issued by the Directorate of Cultural and Natural Heritage of the Guatemalan Ministry of Culture and Sports on 7 May 2013. This dissatisfaction, which reflects a deeper structural tension between ancestral communities and the central government within a broader postcolonial political-cultural context—particularly in Santiago Atitlán (McAnany and Brow 2016)—highlighted three main points of contention: (i) the naming of archaeological sites, (ii) the allocation of archaeological collections, and (iii) the absence of consultation or formal authorization from ancestral authorities.

It is in this context that the Government of Guatemala[2] requested the intervention of a third party by calling for a mission from the Scientific and Technical Advisory Body (STAB), to the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage (UCH). This request was approved during the sixth Meeting of the States Parties, held on 30 May 2017. Two missions were subsequently organized: the first in 2019, and the second in 2022, the latter involving diving operations in Lake Atitlán. During the preparatory meetings held prior to the deployment of the consultative delegation in Guatemala, additional underlying issues were identified by the scientific team appointed for the mission. These included a lack of transparency concerning the non-disclosure of precise geographic coordinates of heritage sites in academic publications—despite these sites being well known to the local community of recreational divers—as well as the coexistence of multiple, often conflicting, archaeological interpretations of discoveries made in the waters of Lake Atitlán (see Montes et al. 2024, p. 119). This plurality of interpretations, combined with the confidentiality surrounding the location of the sites, has generated

[1] Resolución Número 169–2013, Dirección del Patrimonio Cultural y Natural del Ministerio de Cultura y Deportes, Guatemala, siete de Mayo del año dos mil trece.

[2] Guatemala has been a State Party to the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage since 3 November 2015.

confusion—both in terms of understanding the relevant archaeological contexts and in defining the very nature of the submerged heritage. It has also contributed to a climate of mistrust between archaeologists, local authorities, sport divers, and national institutions. This situation could not be overlooked and was, in fact, one of the key factors that prompted a new archaeological assessment.

In this study, we first present the sociocultural context of the region, examining the relationship between Indigenous ontology and underwater cultural heritage, as well as the co-developed methods used during the archaeological assessment conducted in 2022. We then outline the implementation of this approach and its results, along with their implications for defining and understanding the specific underwater cultural heritage of Lake Atitlán. Finally, we discuss the concrete outcomes of the archaeological interventions and the interactions among the various stakeholders, as well as their potential impact on the development of future co-governance policies for underwater cultural heritage—primarily at the regional level, while also opening perspectives for global application.

Lake Atitlán: Environmental and Cultural Context

Lake Atitlán is a high-altitude lake located in the southern highlands of Guatemala. It covers an area of 13,700 hectares (137 km^2) (Fig. 1), with a median water level at ca. 1555 m above sea level (masl). Unlike the tectonic lakes of northern Guatemala, Lake Atitlán was formed as a result of volcanic activity (Brezonik and Fox 1974, pp. 467, 470). The lake is surrounded by several volcanoes, including Volcán Atitlán (3160 masl), which rises on the southern flank of the caldera—within which Lake Atitlán lies—and, together with Volcán Tolimán (3141 masl) and Volcán San Pedro (3028 masl), forms a natural boundary (Haapala et al. 2006).

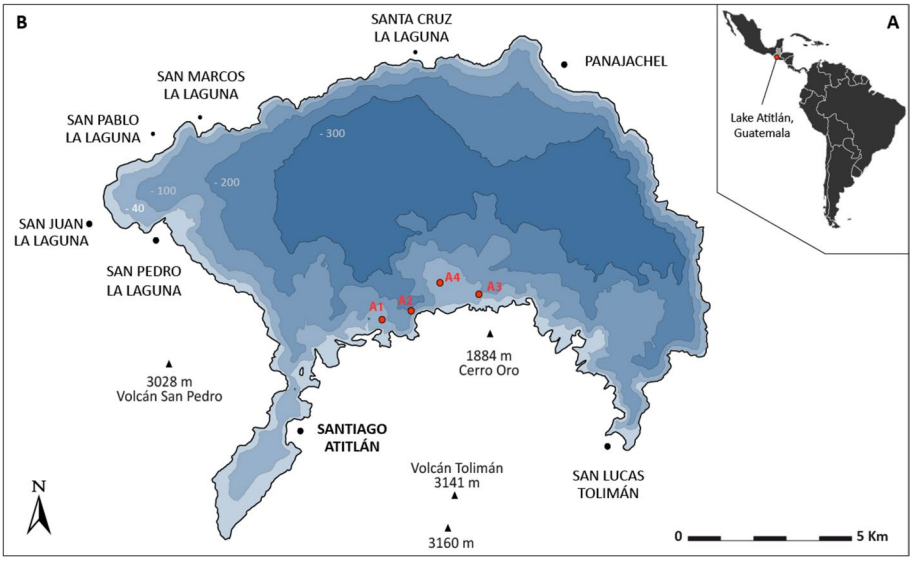

Fig. 1 A. Location of Lake Atitlán and Guatemala at the subcontinental scale; B. Map of Lake Atitlán showing the main towns, bathymetry (adapted from Morales et al. 2018), and four target points investigated during the 2022 UNESCO mission

The current absence of a surface outlet, such as a river, prevents the lake's waters from flowing out of the caldera. This accounts for both its considerable depth—over 300 m—and the significant fluctuations in water levels observed, both in the recent past and historically (Newhall et al. 1987). During the twentieth century alone, records have shown fluctuations exceeding 10 m in amplitude (Newhall et al. 1987, pp. 102–103, Fig. 11), and even today, modern structures can be seen submerged near the shoreline, particularly around the harbor of Santiago de Atitlán.

The water level of the lake results from a complex hydrological balance between evaporation, underground drainage, volcanic activity, and seismic events. This is exemplified by the ~ 2-m drop in Lake Atitlán's water level within a single month following the ~ 7.5 magnitude earthquake of 4 February 1976 (Newhall et al. 1987, p. 102). Understanding the dynamics of lake-level fluctuations and their impact is therefore a key element in studying the underwater heritage of Lake Atitlán. More broadly, it also provides essential insight into the potential effects of natural events on the socio-political development of the region, as has been documented in other lacustrine areas of the American continent (see Guédron et al. 2023).

In addition to the first archaeological synthesis published by Lothrop in 1933—*Atitlán: An Archaeological Study of Ancient Remains on the Borders of Lake Atitlán, Guatemala*—the scientific literature from the second half of the twentieth century suggests that the Maya settled on the slopes surrounding Lake Atitlán during the first millennium BCE, and that their descendants still live around the lake today (Serrano 1970, cited in Newhall et al. 1987, p. 82). More recently, several systematic survey and excavation campaigns (e.g., Bruchez 1997; Davies 2019) have helped to better define the nature and chronology of occupation sites in the Lake Atitlán watershed, while confirming the uninterrupted occupation of the region since the Preclassic Maya period. The results of this research have notably been published as part of two doctoral dissertations.

The first dissertation, defended by Margaret Sabom Bruchez, presents the results of the *Proyecto de Sololá*, carried out between 1993 and 1995 on the northern slopes of the lake (Bruchez 1997). The author offers a regional synthesis based on a classical typological approach (ceramics, architecture, etc.) and demonstrates that the Lake Atitlán basin has been a long-term center of human occupation, from at least the Preclassic period through the Postclassic era. In the second dissertation, Davies (2019), for his part, adopts a similar approach while expanding the analysis to include macro-regional dynamics. Based on surveys and excavations conducted between 2015 and 2016 on the western slopes of the watershed as part of the *Proyecto Arqueológico Lago de Atitlán* (PALA), he highlights continuous occupation beginning around 600 BCE, with particular emphasis on the interactions between human societies and the environment in the volcanic landscape of the Lake Atitlán basin. Both studies confirm the continuity of occupation, especially across the Preclassic (600 BCE–200 C2017E), Classic (200–800/1200 CE), and Postclassic (800/1200–1524 CE) periods, as well as beyond, following colonization and the evangelization of the region from the sixteenth century onward (Luján Muñoz)—a continuity of identity now actively claimed by the contemporary Tz'utujil Maya community.

The Relationship Between Tz'utujil Ontology and Underwater Archaeology

The contemporary Tz'utujil community is a Maya ethnolinguistic group whose ancestral authority—represented by the *Cabecera,* i.e., the community leader—is based at his residence in the town of Santiago Atitlán, located on the eastern shores of a bay connected to the southern part of Lake Atitlán (Fig. 1). Like more than five million people who today identify with Maya ethnicities or nations, the Tz'utujil are the direct descendants of the Indigenous populations that predated the Spanish colonization of the region (McAnany and Brow 2016, pp. 487, 489). The first references to this group appear in sixteenth-century colonial accounts (see Luján Muñoz 2017), corroborating the existence of these communities since at least the Postclassic Maya period. *Tz'utujil*, also known as *achi*, is the mother tongue spoken by this community (Lothrop 1933, p. 15).

Today, Tz'utujil ancestral authorities clearly assert their perspective regarding the collective ownership of archaeological heritage—whether submerged or not—as an essential component of their memory and identity. This approach is not unique, as demonstrated in other contexts, notably along the margins of the North American Great Lakes (Lemke and Freeland 2025), in the Mexican Highlands (Hernández Bautista and Junco Sánchez 2023; Tufiño 2025), and in the Central Andes of South America (Delaere 2022). These cases all share a particular focus on lacustrine environments. In each instance, archaeological diving activities were preceded by prior consultation between researchers and Indigenous communities. The results have shown that, well beyond the principles of consent, the co-appropriation of archaeological sites and local community engagement—through their involvement in the reflective process that underpins the scientific approach—have, to varying degrees, proven beneficial both for ancestral communities and for archaeologists.

Across the Americas, Indigenous populations have developed deep connections with aquatic landscapes (Lemke and Freeland 2025). More specifically in Mesoamerica, this relationship with water remains highly meaningful, rooted in a belief system and worldview inherited from ancestral Indigenous communities. This is particularly well documented, for example, in the Maya region of the Yucatán Peninsula in Mexico (Barba-Meinecke et al. 2023). Ancient Mesoamerican communities viewed water as both a sacred and vital substance: certain lakes, springs, and lagoons were perceived as liminal spaces that enabled communication with the otherworld, as dwelling places for deities or ancestors, or as powerful settings for enacting political performances (Tufiño 2025; Tufiño and Apátiga 2020).

In addition to this broader socio-cultural and ritual context, the identity of the Tz'utujil Maya community is shaped by centuries of struggle and syncretism between ancestral traditions, evangelization, and the socio-political and cultural upheavals that have marked the Americas since the sixteenth century. As a result, the very notion of cultural heritage carries a particular meaning for contemporary Maya populations in the Lake Atitlán region (McAnany and Brow 2016, p. 487). As noted by the authors, "In Santiago Atitlán, Tz'utujil ritual practitioners interact with their past through objects that instantiate both time and their ancestors […]" (McAnany and Brow 2016, p. 487). This quotation clearly illustrates that the Tz'utujil community does not maintain a distanced or merely "museum-like" relationship with objects from the past: rather, such objects—like places—are perceived as agents that embody and connect living entities. In this way, artifacts and archaeological sites themselves acquire an active ontological status in the Lake Atitlán region. This is further reinforced by a cosmogonic dimension: "For the Tz'utujils, Lake Atitlán represents

the most important body of water because it was the place where the world first emerged" (Christenson 2010, p. 74).

It thus becomes clear that the relationship between Indigenous ontology—which grants objects and places the status of active agents and primordial points within the Tz'utujil cosmogony—and the ontologies inherent to the scientific approach must be reconciled in this context. This relationship sheds light, in all its complexity, on the actions undertaken by the Tz'utujil Maya community in connection with diving activities and the discoveries made in the waters of Lake Atitlán. This initiative is all the more forceful and incisive on the part of the ancestral authorities given that, in parallel, Tz'utujil traditions are increasingly under pressure from orthodox Catholic and evangelical groups in the region, who are becoming more hostile to these practices (McAnany and Brow 2016, p. 487). These various factors and actors all contribute to shaping the ontological status of Lake Atitlán and the underwater cultural heritage it contains.

Underwater Archaeology at Lake Atitlán: Background and Precedents

From a scientific perspective, the various underwater archaeological operations carried out in Lake Atitlán are relatively well documented in the Guatemalan archaeological literature, although often only in a very concise manner. Medrano reports that the first dives—some of which aimed to locate archaeological objects—began as early as the 1960s. The gradual development of diving equipment is said to have facilitated increasingly frequent discoveries (*hallazgos*), including those reported in the 1970s by the diver Llarena, who died during one of his dives (Medrano 2009, p. 11). According to Medrano, these discoveries gradually sparked interest in underwater exploration from an archaeological standpoint, eventually leading to the first structured research projects in the 1990s (Medrano 2009, p. 6, 2011a, p. 93).

Although the precise chronology of the earliest dives and discoveries, as well as the exact number of potential archaeological sites identified, remains difficult to establish, the first scientific publication dedicated to underwater research mentions the 1994 excavation campaign conducted as part of the *Proyecto de Rescate Arqueológico Agua Azul*, in a sector vaguely described as the "southern beach of Lake Atitlán" (*Playa sur del Lago Atitlán*) (Barrientos and Benítez Barrios 1997, p. 24). One underwater archaeological site (*hallazgo*) was officially registered by the *Instituto de Antropología e Historia* de Guatemala in 1998 under the name *Samabaj* (Medrano 2011b, p. 93)—a designation that is now contested. In 2000, a private museum, the "Museo de Arqueología Lacustre de Atitlán", was inaugurated in the "Posada de Panajachel hotel", located across the basin on the northern shore of the lake (Mata Amado and Medrano 2011a, b, p. 18).

According to the authors of the first publication, one of the objectives of the *Agua Azul* project was to develop, alongside terrestrial survey and excavation, techniques aimed at "recovering [*rescatar*] materials from the bottom of the lake" (Barrientos and Benítez Barrios 1997, p. 24). Between October and December 1994, a series of dives—planned along transects perpendicular to the shoreline and reaching depths of up to 150 feet (45 m) (Barrientos and Benítez Barrios 1997, p. 25)—led to the discovery of several artifacts, notably ceramic incense burners (Barrientos and Benítez Barrios 1997, p. 24; Montes et al. 2024, p. 117), which, according to the authors, may be associated with underwater offering practices (Barrientos and Benítez Barrios 1997, p. 27). These objects are thought to date from the Preclassic to the Late Postclassic period (Merano 2009, p. 6). Bruchez (1997,

pp. 40–42) additionally reports that these dives were carried out by Mark Hartmann and Michael Fitch of the Department of Nautical Archaeology at Texas A&M University.

Some time later, as part of his *licenciatura* thesis, one of the authors, Henry Benítez Barrios, reported: "Several years [after 1994], I was informed of the existence of structural foundations at the bottom of the lake, near Cerro de Oro" (Benítez Barrios 2001, p. 3). This account and its location—offshore from Cerro de Oro—correspond to the underwater archaeological site officially registered in 1998 under the name *Samabaj*, which subsequently became the focus of his research, particularly within the framework of his thesis. Between April 9 and 16, 1999, guided and accompanied by Roberto Samayoa—the diver who discovered the site—they identified and recorded several structures. According to their classification, this included three residential groups (*grupos habitacionales*, numbered 1 to 3), of which only two were mapped, as well as five isolated structures (*estructuras*, numbered 3 to 7). Finally, a carved basalt stela, referred to as Monument No. 1, measuring 1.20 m in height and 60 cm in width, was also documented (Benítez Barrios and Samoya 1999, pp. 690–691; Benítez Barrios 2001, pp. 25–26).

A more comprehensive understanding of the site in question would only emerge with the operations directed by Sonia Medrano between 2008 and 2011. These efforts were preceded, in 2007, by a geophysical sonar survey conducted by the 'Scripps Institution of Oceanography' (California), focusing in particular on the site of *Samabaj*. This study contributed to a better understanding of the site's topography and reportedly identified a series of anomalies and potential archaeological remains (Medrano 2009, pp. 3, 7). The *Samabaj* site appears to correspond to a geological formation in the shape of a submerged hill (i.e., a now-submerged paleo-island), measuring 477 m from north to south and 340 m from west to east, covering an area of approximately 160,000 meters^2 (16 hectares), with its summit lying 45 feet (14 m) below the surface in the northeastern part of the former island (Medrano 2009, p. 8). Based on these results, the first dives were undertaken: 27 immersions in total, carried out between August 2008 and March 2009. These led to the identification and documentation of twelve distinct clusters across the site, composed of grouped structures and organized, as in Benítez Barrios (2001), into various named groups: (i) *Cuadro*, (ii) *Jackpot*, (iii) *Max*, (iv) *Cuadras*, (v) *Círculos Gemelos*, (vi) *Círculo*, (vii) *Óvalo*, (viii) *Piedra*, (ix) *Estela*, (x) *Estela Sisa*, (xi) *Plato*, and (xii) *Roca* (Medrano 2009, pp. 8–14). Medrano provided a narrative description of these groups, accompanied by site sketches, and, for the first time, a general (non-georeferenced) site plan indicating their location, distribution, and orientation within the submerged area (Medrano 2009, p. 20, Fig. 2) (Fig. 2).

Diving operations resumed in February 2010 (Medrano 2011a), and again from 4 to 14 May 2011 (Medrano 2012). The reports and conference proceedings resulting from these campaigns (Medrano and Samayoa 2010; Medrano 2011a, 2012) complement the previously published descriptions and site plans, and refined the overall understanding of the site. It appears to include a ceremonial area with a public plaza and stelae, residential sectors composed of quadrangular structures, as well as specialized zones such as former boat docks (Medrano and Samayoa 2010; Medrano 2011a, 2012). In addition, excavations were carried out in 2010 within the *grupo cuadros* sector and on the *banqueta norte* of *monumento 1*—previously referred to as *grupo estela* (Medrano 2012).

These excavations revealed, among other findings, that "the edge [of structure no. 3 in *Grupo Cuadros*] is composed of a row of rectangular stones, nearly all of which were cut on all sides"; that fragmented and eroded ceramic sherds ($n = 959$) were recovered inside the structure, along with obsidian tool fragments; and that it is highly probable these stone alignments "served as a foundation to support a structure made of perishable materials"

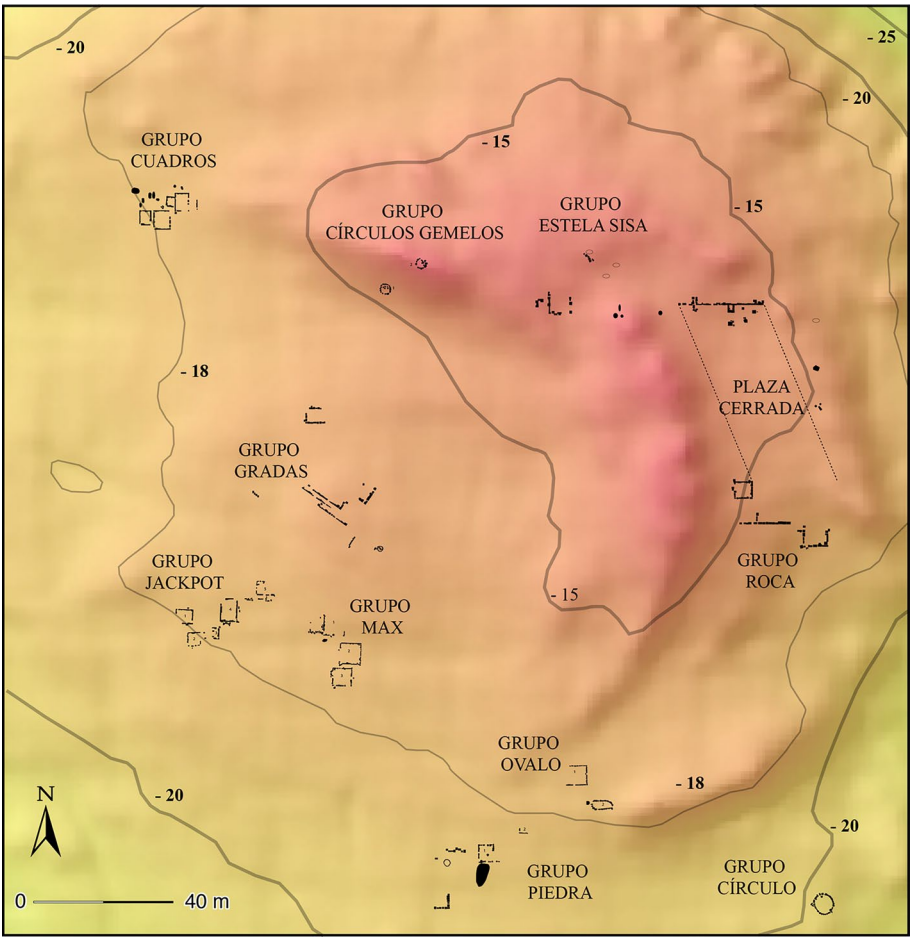

Fig. 2 Original plan of Site A4 (i.e., Samabaj) combining both the archaeological map of the site (adapted from Medrano 2009, p. 20, Fig. 2) and the digital elevation model (DEM) produced in 2011 by John Hale (personal communication, December 2021)

(Medrano 2011a, p. 6). According to Medrano (2011a, p. 6), the artifacts "belong primarily to the Late Preclassic period". Finally, in the *banqueta norte* sector of *Monumento 1*, the excavations led to the association of several architectural elements grouped under the designation *plaza cerrada*. The 2010 season report also includes numerous descriptions and drawings of archaeological materials and *hallazgos*, as well as the transcription of local oral traditions relating to legends of the lake (Medrano 2011a).

Methodology: A Collaborative and Co-constructive Approach

The need to carry out a new archaeological assessment was formulated and approved by the Tz'utujil Maya community in 2019. It was expected that the actions leading to this assessment, while meeting the scientific standards of archaeological practice, would be

conducted in a collaborative manner, with full transparency, and in accordance with both the Tz'utujil ontology and national legal frameworks. From an archaeological standpoint, the needs expressed were as follows: (i) to locate the underwater archaeological site(s), (ii) to conduct a diagnostic evaluation of any sites potentially identified, and (iii) to fully understand the nature of the underwater cultural heritage specific to Lake Atitlán. The spirit of the project was grounded in a collective approach aimed, on the one hand, at creating a pilot project in community-engaged archaeology, and, on the other hand, at paving the way—over the medium term—toward the co-management and shared governance of this heritage.

A transparency commission was established by the community to appoint members responsible for participating in each archaeological activity. Additionally, at least one local volunteer diver—approved by the community—was trained in underwater techniques to accompany archaeologists underwater: Xelani Luz. This point speaks to the broader and recurring issue of access to heritage. The principle upheld is that heritage, even when "inaccessible" due to submersion, can and must be returned and transmitted to the Tz'utujil community, across all generations. In this sense, beyond the training of a local diver, photogrammetry and 3D reconstructions of the remains were among the concrete deliverables expected by the community; such models enable the intelligible and objective dissemination of underwater remains to a wider audience.

More broadly, it was expected that the full body of knowledge—whether from the current mission or from previous research—would be shared not only with members of the Tz'utujil community, but also with the scientific community beyond Guatemala's borders, as has been the case with other UNESCO missions, such as the one in Paraguay (Elkin et al., in press; Delaere et al. 2026). Beyond the responsibility of publication and dissemination incumbent upon archaeologists, this paper also forms part of that commitment. It is worth noting that a Guatemalan archaeologist-diver, Miguel Medina, also took part in the diving activities.

To address the scientific questions and objectives, six main actions—co-defined and agreed upon by all stakeholders—were selected (Table 1). To carry out these six actions, the primary challenge was therefore to locate at least the main archaeological site—*Samabaj*—since the success of the mission and of the five subsequent actions depended on its identification. To address this, the following strategy was adopted: first, four potential targets were georeferenced using GPS during the 2019 UNESCO mission, in collaboration with members of the Tz'utujil community and the Directorate of Cultural and Natural Heritage of the Guatemalan Ministry of Culture and Sports: A1, A2, A3, and A4 (Figs. 1, 3). Second, these four points were entered into a geographic information system (GIS), in conjunction with a bathymetric map drawn from the scientific literature—particularly Morales et al. (2018, pp. 48–58)—as well as the map produced in 2019 by the *Autoridad para el Manejo Sustentable de la Cuenca del Lago de Atitlán y su Entorno* (AMSCLAE). Finally, the results were cross-referenced with published scientific descriptions of the site to determine which of the points (A1–A4) most likely corresponds to the site referred to as *Samabaj*, and to narrow down the search area.

It was therefore necessary to carry out a new geophysical survey to precisely locate the site, as well as its shallowest point, previously reported at 14 m (46 feet) depth (Medrano 2009, p. 8). This step was also essential for defining the hyperbaric intervention procedures and ensuring both the smooth execution of the operations and the safety of the divers. This first action, conducted in 2022, involved acquiring new bathymetric data over the four previously identified targets. The team used a Panoptix™ PS30 multibeam echosounder paired with a GPSMAP® 7410 unit. Nearly seven hours of navigation—covering approximately

Table 1 Correlation between objectives, methods/tools, and the role of the community

	Actions/objectives	Methods/tools	Role of the community
1	Locate the underwater archaeological site(s)	Geophysical survey; analysis of bathymetric maps; review of scientific literature	Participation on the boat; identification of areas referenced in oral tradition; recording of local toponyms used by the community
2	Verify targets identified through bathymetric analysis	Diving	Participation on the boat
3	Document the archaeological remains	Diving; photography; video; photogrammetry; site drawings and sketches	Participation on the boat; underwater accompaniment by a community member
4	Conduct a diagnostic test pit excavation (stratigraphic analysis)	Diving; excavation of a test pit using a water dredge; recording and sampling of artifacts	Participation on the boat; collective analysis of artifacts on board; reburial of artifacts in the test pit
5	Process and interpret the archaeological data	Analysis and processing of data (observations, drawings, 3D models, etc.), cross-referenced with scientific literature	Collective discussion of results, first in a working group, then in a community assembly
6	Formulate site management recommendations	Participatory discussion in a community assembly	Joint development of recommendations for the co-management of the underwater cultural heritage

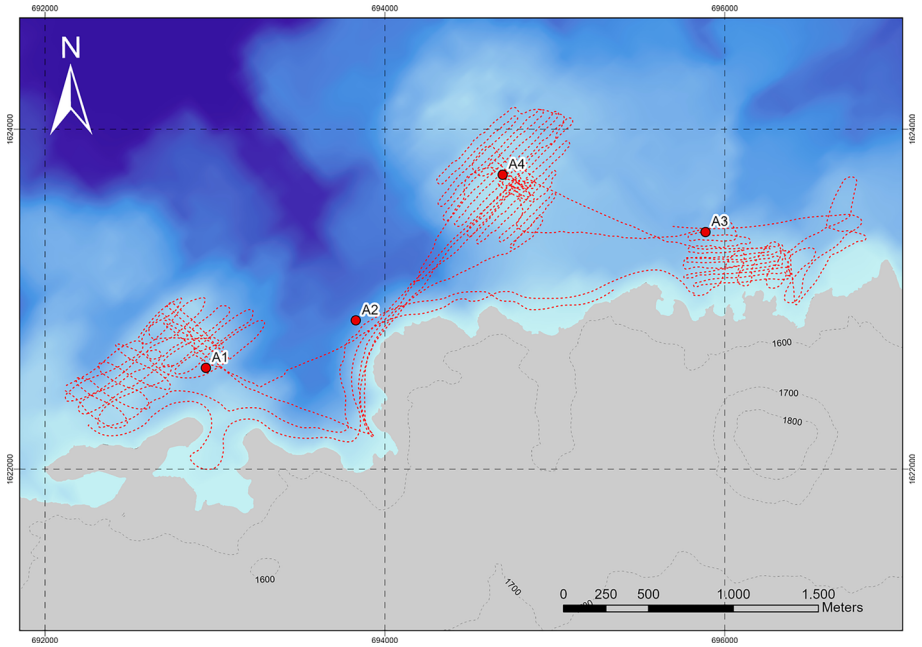

Fig. 3 Detail of Lake Atitlán showing the four georeferenced target points investigated during the 2022 UNESCO mission (see Fig. 1), together with the trajectory of the geophysical survey conducted to acquire new bathymetric data

70 km of transects (Fig. 3)—enabled the mapping of a total surface area of 3.78 square kilometers, representing nearly 3% of the lake.

Once this first action was completed, the second consisted of conducting dives at the target locations—particularly at point A4—following standard survey procedures (Maarleveld et al. 2013); in this case, circular survey methods were employed. Over the course of four days, totaling approximately 2400 min of dive time, eight divers took turns to successfully locate the *Samabaj* site at point A4 and to identify as many remains as possible within a predefined depth range—between 13 and 21 m—based on available data and safety protocols.

Since the site's location had been confirmed, the third action step consisted of documenting the remains through video and photography using GoPro 8 and 9 devices, as well as a Sony Alpha 7C ILCE-7C camera. Photogrammetric models were also produced following established methodologies (see Cerezo Andreo et al. 2025; García-León et al. 2017; Solana Rubio et al. 2023). During seven 30-min dives, a total of 4000 vertical photographs were captured across four distinct submerged sectors of site A4. These images were processed using Agisoft Metashape to generate both 3D models and various digital elevation models (DEMs), covering a total surface area of 3240 square meters.

The fourth action step involved conducting a micro (50×50 cm) test pit excavation to evaluate the nature and rate of sedimentation through stratigraphic analysis, in relation to the theme of water level fluctuations at Lake Atitlán. The goal was to characterize the composition of the subsurface (sediment, paleosol, etc.) in order to complement the surface data recorded on the lakebed. To this end, a water dredge was used, and the sediment

analysis was carried out following established methodologies. For example, carbonate-rich sediments are typical lacustrine deposits that provide information on lake-level changes (see Delaere and Guédron 2022; Delaere et al. 2023). A single test pit, 41 cm deep, was excavated in the presence of the community diver at site A4. The unit was located at a depth of 15.4 m (i.e. 1542.6 masl). It was positioned on the eastern edge of the archaeological site, 20 m west of *Monumento 1*. Distinct stratigraphic units were recorded, each described in terms of depth, composition, lithology, and the presence or absence of archaeological material. Ceramic fragments were collected, analyzed onboard the boat, and then returned to the bottom of the test pit, which was subsequently backfilled. The final steps—namely the processing, interpretation, and dissemination of the data—were carried out on site following the approach outlined at the beginning of this section, in the presence of all project stakeholders, including members of the Tz'utujil Maya community.

Archaeological Results

Beyond the fact that the successful implementation of the methodology described constitutes a result in itself (Table 1), the first archaeological outcome lies in the concrete localization of the site (known until then as *Samabaj*), identified as site A4 in our nomenclature, along with the precise recording of its GPS coordinates for purposes of future co-management and protection (Table 2). The site's location had not been consistently agreed upon between the information provided by the community, the Ministry, and the scientific literature. According to an internal report from the Ministry of Culture and Sports (Rodas 2014, p. 5), the published coordinates more or less matched the area designated as point A4 during the 2019 mission—an assessment that aligned with our geomorphological and bathymetric analysis of the lakebed. However, those coordinates delineated a polygon covering an area of 5.8 square kilometers, which raised two major issues: (i) it would have been physically impossible to carry out a comprehensive underwater survey over such an extensive zone within the planned framework (only six days of diving were authorized in 2022); and (ii) it was unthinkable to deploy divers "blindly" in this area, given that depths can exceed 130 m—an especially risky context in a high-altitude environment, where increased nitrogen saturation heightens the risk of decompression accidents (Delaere and Rambaud 2024).

Relying on our own bathymetric surveys, we selected the shallowest point, located on a bathymetric elevation to the southeast of point A4, situated offshore from Cerro de Oro. In parallel, we superimposed the site plan established by Sonia Medrano and her collaborators onto the figure of the digital elevation model (DEM) produced in 2011 by John Hale (Fig. 2), which he kindly shared with us via email in December 2021. The cross-referencing of these two data sources, combined with prior knowledge of depth ranges and

Table 2 GPS coordinates of Site A4 recorded during the 2022 UNESCO mission (EPSG: 32615; WGS 84/UTM Zone 15N)

Name	Medrano (2010)	Coordinates (EPSG: 32,615; WGS 84/UTM zone 15N)	
		X	Y
A4	*Samabaj*	694,824.55	1,623,706.111
		694,827.725	1,623,607.95
		694,781.13	1,623,606.443
		694,777.955	1,623,704.604

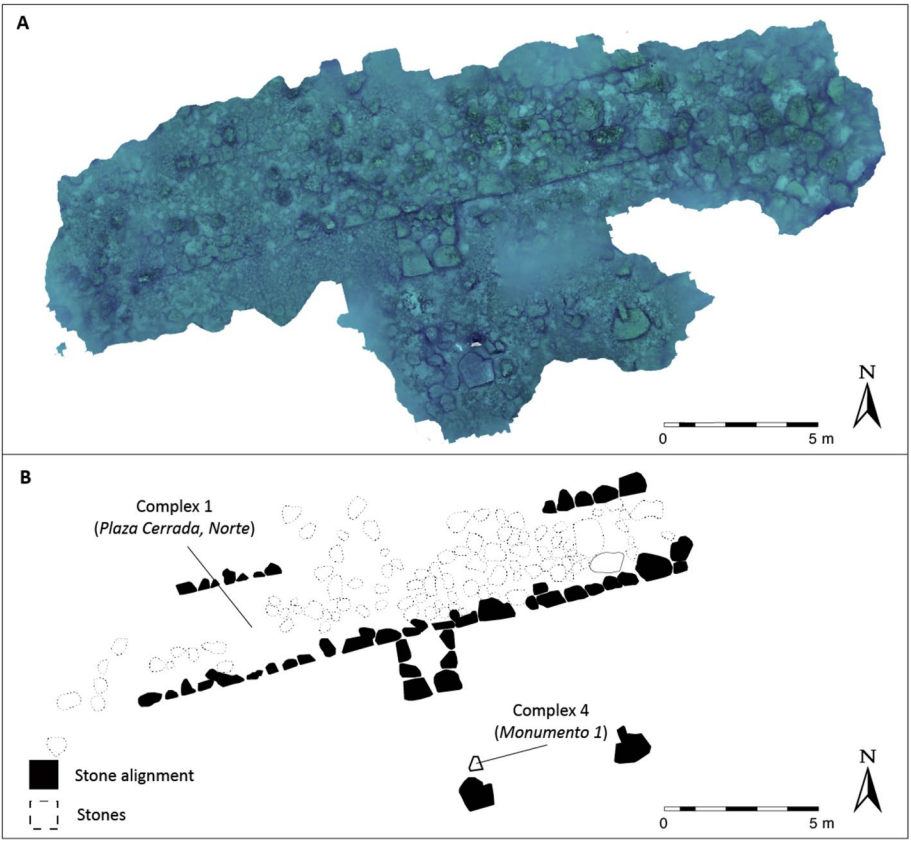

Fig. 4 A. Photogrammetric model; B. Archaeological drawing of the monumental structure located north of Complex 1 (*Plaza Cerrada*), investigated during the 2022 UNESCO mission

underwater orientation protocols, enabled the dive team to recognize and identify—during the very first immersion—the archaeological site, including a series of features corresponding to the coherent archaeological units (i.e., *conjuntos*) previously documented by our predecessors (Medrano and Samayoa 2010; Medrano 2011a, 2012).

The second key result lies in confirming the nature of the underwater archaeological remains. The processing and analysis of the data collected in 2022 demonstrate that these remains belong to a submerged Maya cultural landscape—specifically a paleo-island with architectural complexes. Notably, the northern section of Complex 1 (*Plaza Cerrada*) clearly illustrates the presence of monumental architecture, while Complex 2 (*Grupo Cuadros*) provides indisputable evidence of stone foundations belonging to a complex composed of at least three quadrangular structures.

More specifically, the diving operations carried out over six days allowed for the (re) documentation of a total of five architectural complexes, which we refer to using the previously established nomenclature in order to ensure better consistency between earlier publications and the present study: (i) Complex 1 (*Plaza Cerrada*), (ii) Complex 2 (*Grupo Círculos Gemelos*), (iii) Complex 3 (*Grupo Cuadros*), (iv) Complex 4 (*Monumento 1*), and (v) Complex 5 (*Estela Sisa*).

The northern section of Complex 1 (*Plaza Cerrada*) consists of a rectangular structure measuring at least 18.8 m in length by 3.5 m in width, oriented west–east with a 9.5° deviation toward the south (Fig. 4). The southern façade features a carefully constructed stone alignment approximately 40 cm in height, with several segments also preserved along the northern side; the space between them is filled with clusters of stones. The structure likely corresponds to a platform, unquestionably built and intentionally arranged by human activity prior to the site's submersion. This platform is preceded, on its southern side, by a small adjacent rectangular structure measuring 2.1 m (north–south) by 1.9 m (west–east). Located 2.6 m south of the platform is Complex 4, identified in the literature as a stela measuring 1.2×0.6 m and referred to as *Monumento 1*, associated with an altar (Benítez Barrios and Samoya 2000, pp. 690–691; Benítez Barrios 2001, pp. 25–26). At this stage of research, it is difficult to determine whether the platform continues beyond what is currently visible, but it appears to close off the northern edge of a broad, flat area, bounded to the west and east by two natural rock ridges oriented northwest–southeast. This zone has been interpreted in the literature as a public space or *plaza cerrada* (Medrano 2011a). Additional structures have also been identified and recorded within this flat area, notably those we designate as the central-eastern and southern (or *plaza sur*) sections of Complex 1 (Barba-Meinecke et al. 2022, figs. 43–46).

Complex 2 (*Grupo Círculos Gemelos*) consists of two small rectangular structures with rounded corners, oriented NW–SE and located 8.3 m apart. The first measures 2.6×2.1 m and features a sort of entrance passage on its southeastern side; the second measures 3.1×3.0 m (Fig. 5). This was the first complex identified during the dives at the site. Had other archaeological structures—such as Complex 1—not been observed, some doubt might have remained regarding the anthropogenic nature of this complex, particularly within a sublacustrine environment of volcanic origin.

Complex 3 (*Grupo Cuadros*) is an architectural complex composed of at least three quadrangular structures made of aligned cut stones, likely representing foundations (Fig. 6). The structures are oriented west–east, with an approximate deviation of 2° toward the south. The westernmost structure measures 4.0 m (N–S) by 3.9 m (W–E), with a

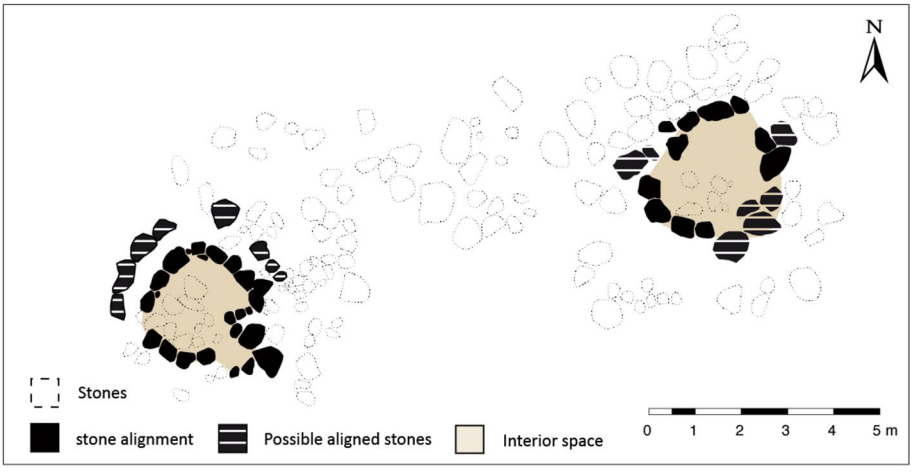

Fig. 5 Archaeological drawing of the structures of Complex 2 (*Grupo Círculos Gemelos*), investigated during the 2022 UNESCO mission

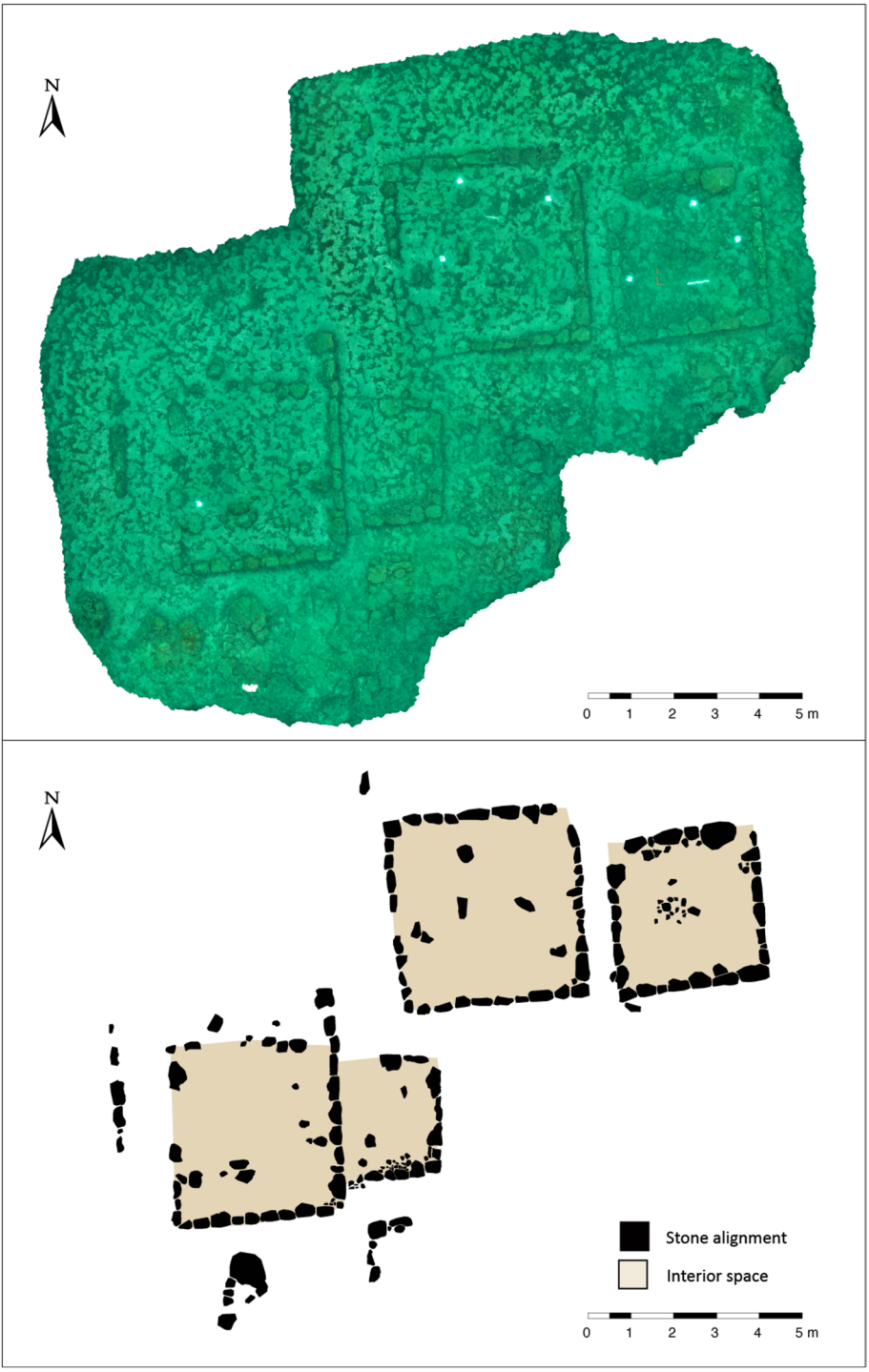

Fig. 6 A. Photogrammetric model; B. Archaeological drawing of the structures of Complex 3 (*Grupo Cuadro*), investigated during the 2022 UNESCO mission

Table 3 Descriptions of the stratigraphic units from the test pit excavation conducted at Site A4

Unit	Depth	Description	Artefacts
Unit 1	0–6 cm	Root layer and carbonate volcanic sand	Yes
Unit 2	6–13 cm	Anaerobic decomposing organic layer	No
Unit 3	13–17 cm	Fine black volcanic sand layer	No
Unit 4	17–25 cm	10–40 cm stones within a brown silty-sandy layer	Yes
Unit 5	25–41 cm	Coarse black granular volcanic sand layer	No

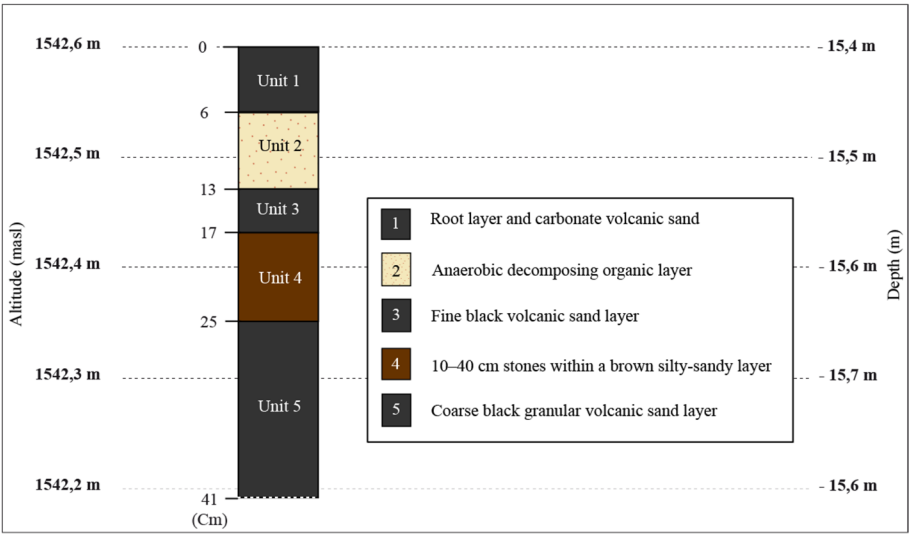

Fig. 7 Stratigraphic log, depth, absolute elevation, and sediment characterization from the archaeological test pit excavation carried out during the 2022 UNESCO mission

small adjoining room to the east measuring 2.7 × 2.4 m. The central structure measures 4.3 × 4.3 m, and the eastern one measures 3.5 m (N–S) by 3.4 m (W–E). In certain areas, these foundations display a double-facing technique with internal infill—similar to construction methods observed elsewhere on the site. Wooden elements, likely belonging to collapsed superstructures, were also observed in the surrounding sediment. This architectural complex, in particular, has been interpreted as a remarkably well-preserved example of Maya house foundations dating to the end of the Preclassic period (Linares Palma and Medrano 2010; Davies 2019, p. 75).

Complex 4 (*Monumento 1*) corresponds to the stela previously described, located facing the southern façade of Complex 1. It consists of a vertically standing stone, accompanied at its southern base by a horizontal stone interpreted as an altar (Medrano 2011a). No markings were observed on the stela.

Complex 5 (*Estela Sisa*) appears to be another unmarked stela. Its distinctive feature lies in the fact that the worked, upright stone—measuring 1.2 m in height—is set within what is likely a quadrangular structure measuring 3.3 × 3.3 m, oriented west–east with a 10° deviation toward the north.

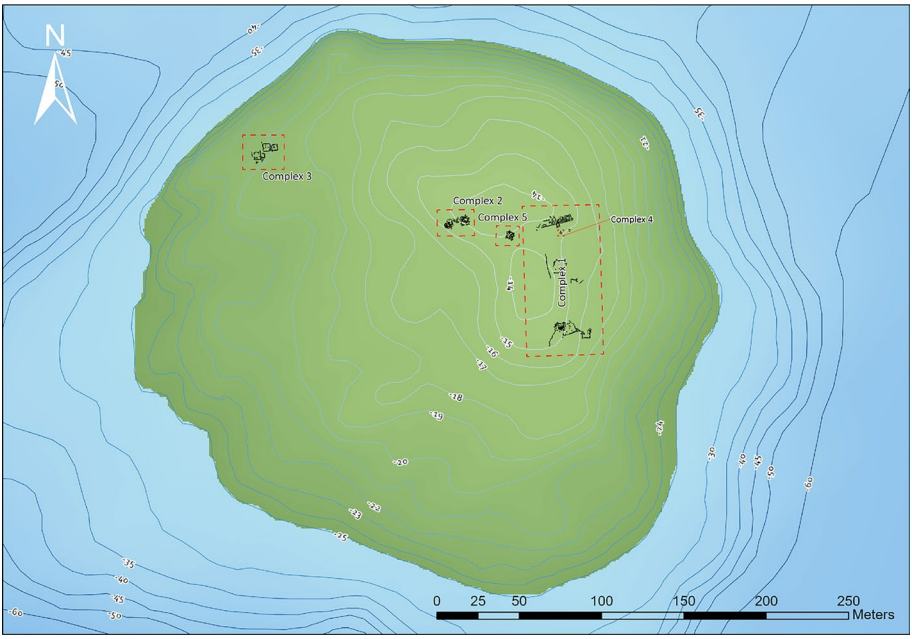

Fig. 8 Spatial distribution (5 m margin of error) of the various structures grouped into complexes, studied and recorded during the 2021 UNESCO mission

Finally, in addition to the surveys and prospections, the aforementioned test pit excavation was carried out 20 m west of Complex 4, or *Monumento 1*. The sediment revealed five distinct stratigraphic units (Table 3, Fig. 7).

Ceramic fragments were associated with Units 1 and 4. The eroded sherds from Unit 1 indicate sediment disturbance typical of a submerged but shallow lake level, whereas the unweathered fragments from Unit 4, combined with the silty-sandy sediment low in organic matter, suggest the existence of a paleo-terrestrial layer that was rapidly submerged. Although the stratigraphic sequence is short (41 cm), it was excavated over the course of 60 min and already reveals evidence of several episodes of lake-level fluctuation in this area. Specifically, it shows: (i) phases of more or less carbonate-rich lacustrine deposits corresponding to varying water levels and/or volcanic activity (Units 1 and 3); (ii) an organic layer preserved in anaerobic conditions during a rise in lake level (Unit 2); and (iii) a potential paleo-terrestrial level at a depth of 15.55 m, or 1542.45 m above sea level (Unit 4).

These observations provide the first geomorphological and archaeological evidence for understanding the formation processes of the site in connection with one or more flooding events that led to the abandonment of the settlement—now located between 12 and 30 m below the current lake level—thus revealing a remarkable amplitude of past lake-level fluctuations. The analysis of ceramic fragments from Unit 4 (carried out on board the vessel by María Mercedes Acevedo Reyes), along with an associated obsidian flake, suggests that the sherds recovered from the test pit date to the Late Preclassic Maya period (350 BC–250 AD). They thus potentially mark the final phase of occupation prior to the natural event that triggered the site's abandonment. In accordance with the agreements established with the community, all archaeological materials discovered were presented to

the members present on the boat and subsequently returned to their original context after analysis—that is, they were reburied at the bottom of the test pit within the lake.

All of the architectural complexes located and recorded during the 2022 UNESCO mission were, for clarity, plotted on a site map using the geo-referenced surface buoys as reference points (Fig. 8). However, as the objective of the mission was not to fully map the site or to articulate the architectural complexes in relation to one another to produce a complete plan—which would have required the implementation of a specific topographic procedure based on a fixed reference point—their positioning carries an estimated margin of error of approximately 5 m. Nevertheless, the preliminary results indicate, on the one hand, that earlier site plans contained orientation and scale inaccuracies—which have limited consequences, as illustrated by Complex 3 (*Grupo Cuadro*) (Fig. 9). More importantly, the distances between the identified complexes—generally situated on less sedimented elevations—suggest the existence of a high density of architectural structures over a very large submerged area. This is a truly exceptional and unique finding within the Mesoamerican region.

Discussion

Clearly identifying the nature of this heritage was a central issue in the context of this research, particularly when it comes to distinguishing between a practice of "underwater offering," as suggested by some authors (Barrientos and Benítez Barrios 1997, p. 27), and a "submerged cultural landscape." These two notions carry very different meanings—both within the field of archaeology and in Tz'utujil perceptions. On the one hand, we are dealing with intentional, ritualized deposits in aquatic environments, as exemplified by offerings in Maya cenotes (Barba-Meinecke et al. 2023) or in the Inca and pre-Inca cultural sphere of South American lakes (Delaere et al. 2019; Delaere and Capriles 2020). On the other hand, we are referring to remains naturally submerged due to fluctuations in lake levels, without any anthropic intention. The distinction between intentional [offerings], natural [inundation], and accidental [e.g. shipwreck] processes has a major impact on how

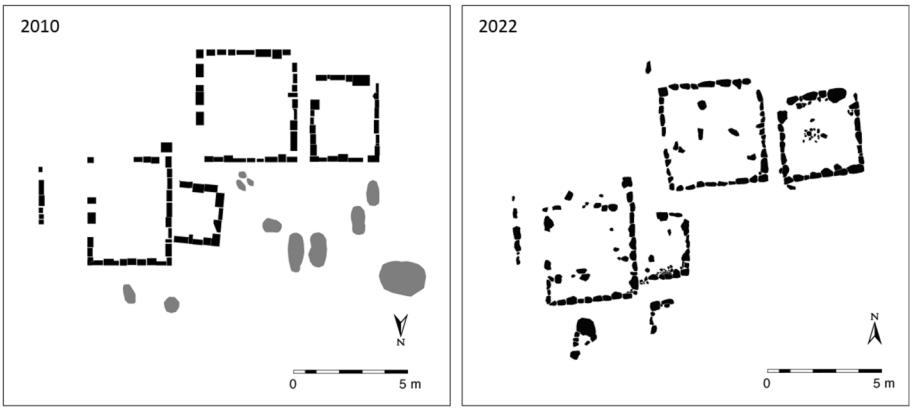

Fig. 9 Comparison of the archaeological surveys of the submerged structures belonging to Complex 3 (*Grupo Cuadro*), between 2010 (adapted from Medrano 2009) and the one carried out during the 2022 UNESCO mission

submerged cultural heritage is interpreted, perceived, and managed in Maya territory—as it does elsewhere.

Based on the results obtained, site A4 clearly corresponds to a submerged site that falls squarely within the definition of a "submerged cultural landscape"—a category that remains particularly under-documented in the region. Indeed, most case studies and research themes related to underwater cultural heritage in the Americas focus—though not exclusively—on navigation, underwater offerings, the exploitation of natural resources such as fishing, the perception of aquatic landscapes within Indigenous belief systems and cosmologies, port areas, and shipwrecks (see Elkin and Delaere 2023).

Submerged cultural landscapes generally refer to the remains of former coastal maritime environments located on the continental shelf. These landscapes were submerged due to post-glacial sea-level rise following the Last Glacial Maximum around 22,000 years ago, during a period when ocean levels ranged from 130 to 110 m below their present level (e.g., Bynoé et al. 2023). Over the past few decades, the identification of these submerged landscapes—often facilitated by diving activities—has significantly reshaped our understanding of settlement dynamics and exchange systems (Conolly and Ward 2022). Less well known are submerged cultural landscapes in inland waters, whose study remains unevenly distributed across the globe. Although the submersion process responds to other mechanisms occurring during the Holocene (rather than following the last glacial maximum), it also concerns territories once occupied by humans that are now submerged. Some regions have been extensively researched, such as the lakes of the Alpine arc (e.g., Magny et al. 2012) or those of North America (Conolly and Obie 2021), while examples from the Southern Hemisphere remain comparatively rare (see Ward et al. 2022), including those documented in the Argentine maritime space (Elkin et al. 2023) and in the inland waters of the Central Andes (Delaere and Guédron 2022; Delaere et al. 2023). The confirmation of a submerged cultural landscape in Lake Atitlán thus holds considerable scientific potential, particularly as its study may yield unique data, often preserved under anaerobic conditions (Conolly and Ward 2022). Beyond these specificities, the identification of the site and its initial documentation already constitute a significant advancement—both for the discipline of pre-Hispanic archaeology and for the broader scientific community working in the Maya region.

The study of submerged cultural landscapes also allows, as confirmed in the case of Lake Atitlán, for the identification of brief and sudden events (Conolly and Ward 2022, pp. 1–2), as well as the short- and medium-term cultural responses associated with them—such as site abandonment or the emergence of underwater ritual practices (see Davies 2019, pp. 61–64 for a synthesis)—which are often invisible in conventional environmental archives. Site formation indicators and taphonomic observations suggest a remarkable state of preservation of the remains at Lake Atitlán, potentially including wooden elements belonging to the superstructures of buildings, preserved within the sediments. All of these factors reinforce the hypothesis of a sudden submersion event of the former island, which may have favored the conservation of these remains beneath a sufficiently deep water column to protect them from currents and wave action—both of which typically contribute to the erosion of archaeological sites located at shallower depths.

Additional information also appears in various reports, including observations made by recreational divers, such as the following: "He sometimes found pottery at the bottom, but he noticed that depending on the depth, the ceramics had different characteristics. After consulting publications and speaking with experts, he concluded that some belonged to the Late Classic period, while those located deeper corresponded to the Preclassic period" (Medrano and Samayoa 2010, p. 324). This observation is significant for several reasons,

as it helps to establish a link, for instance, between the objects recovered during the *Agua Azul* project (Barrientos and Benítez Barrios 1997), off the modern southern shores of Lake Atitlán, and those uncovered at the deeper offshore site of A4/*Samabaj* (Medrano 2009). This suggests that more than one underwater archaeological site may exist in Lake Atitlán: on the one hand, at least one presumed submerged site from the Preclassic period (600 BC–200 AD) (Medrano 2015); on the other, closer to the shoreline, later material attributable to the Classic period (200–800/1200 AD), including six incense burners dated to the Middle Classic (Davies 2019, p. 63). According to one interpretation by Davies (2019, p. 63): "The subsequent increase in water-related ceremonies, involving the use and discard of elaborately decorated incense burners featuring quincunx symbols and ceiba tree spikes, no doubt served to commemorate this dramatic flood and to ensure that such an event would not recur". Rather than choosing one interpretation over another, it thus seems likely that different types of underwater heritage coexist in Lake Atitlán—including submerged habitation sites and underwater offering contexts.

The development of a collaborative and co-designed approach between Indigenous communities and scientists thus opens up promising avenues for future research. The results obtained are not only a direct outcome of this approach, but—through their nature and their appropriation by the community—they also define key elements for the ongoing elaboration of a co-management and governance model for Guatemala's underwater cultural heritage. At the time of writing, the community has also selected three names in the Tz'utujil language to rename Site A4/Samabaj, in alignment with the local ontology. From an archaeological perspective, the acquisition of new bathymetric data across the four targets investigated during the mission also opens broader horizons for research and collaboration. Indeed, projections of lake-level fluctuations at Lake Atitlán during the Preclassic Maya period—based on the elevation of the architectural remains—allow us to propose a model of paleoenvironmental and geomorphological reconstruction of the island before its submersion, which can be applied to other areas surveyed. This model, presented in cartographic form, indicates the possible existence of other paleo-islands in the lake, notably at Site A1 (Fig. 10), as well as an entire lakeshore area now submerged but with potential archaeological significance, as demonstrated by the *Proyecto Agua Azul*. The case of Site A4—already exceptional—thus may not be unique within Lake Atitlán.

Conclusion

The results obtained in the waters of Lake Atitlán during the 2022 UNESCO mission are part of an unprecedented process of collaboration between the Tz'utujil Maya community, the Guatemalan government, and the researchers involved, thereby proposing an initial framework, or at least a new tangible experiment, for the development of community-engaged archaeology in the region. Beyond the archaeological data itself, the strength of this approach lies in the co-definition of scientific objectives and the collective formulation of outcomes, which provided the data's of the present study. This paper introduces, in relation to the concept of the "Submerged Cultural Landscape," an additional dimension through an explicit commitment to more inclusively integrate Indigenous ontologies—not only into the results, but also into the conduct of research and the design and implementation of future heritage policies. In an increasingly globalized world, this research is an additional example of the importance of fostering the co-construction of scientific knowledge

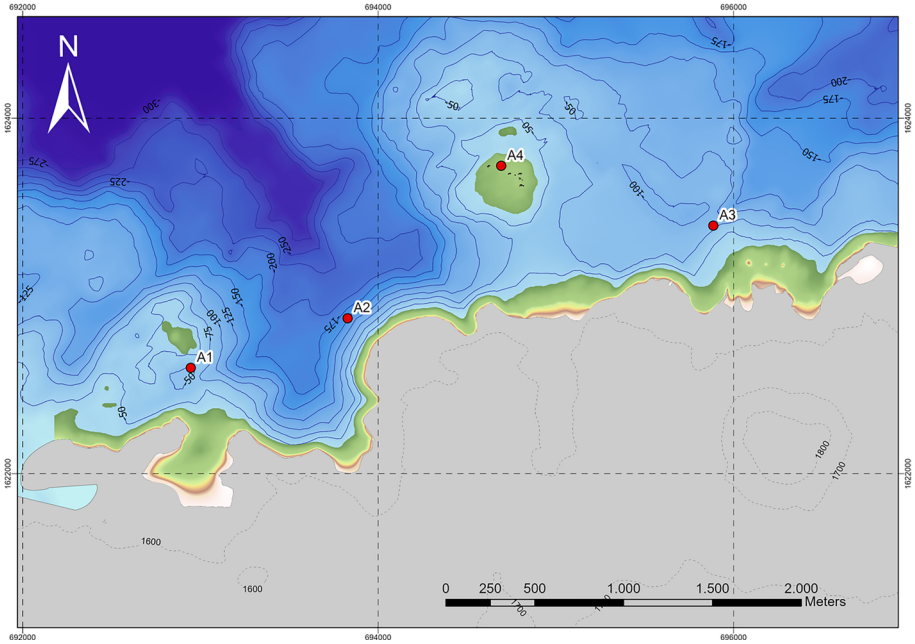

Fig. 10 Hypothetical reconstruction of Lake Atitlán's level at the end of the Maya Preclassic period, highlighting studied site A4 (i.e., *Samabaj*), the existence of other paleo-islands to the west (A1), as well as the submerged areas along the lakeshore

and, in the longer term, the emergence of shared forms of cultural heritage management and governance.

From an archaeological perspective, the characteristics defining a submerged cultural landscape closely align with previous observations made at Lake Atitlán. First and foremost, the identification of stone foundations belonging to architectural structures—some of which exhibit monumental features—constitutes a major line of evidence. Furthermore, the bathymetric surveys, combined with data on lake-level fluctuations, demonstrate that the area investigated—particularly the site studied in this research—was once an inhabited and modified island during the Preclassic period. This island appears to have been inundated and eventually fully submerged by the lake following one or more natural events, whether volcanic, seismic, or linked to an increase in precipitation, most likely toward the end of the Preclassic Maya period. The nature and scale of the site make it an exceptional and unique case within the Mesoamerican region.

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Author Contributions Author contributions: H.B.M. and C.D. designed research; H.B.M., C.D., D.E. and F.C.A. performed research; H.B.M., C.D., D.E. and F.C.A. contributed new reagents/analytic tools; H.B.M., C.D., D.E., F.C.A., L.Z., M.M.A., M.M. and J.L.R. analyzed data; C.D. wrote the paper. All authors reviewed the manuscript.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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