GPR Investigations at the Coqueiro Submerged Archaeological Site in the Maranhão Lowlands, Eastern Amazon: Preliminary Results

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Abstract

This work presents the results of a geophysical survey using Ground Penetrating Radar (GPR) at the Coqueiro submerged archaeological site, located in a lake in Olinda Nova do Maranhão (MA), eastern Amazon. The aim was to detect buried wooden structures and ceramic concentrations associated with ancient stilt house villages. Organic preservation in this region is favored by peat accumulation in water bodies. Data were acquired during the first stage of fieldwork using a 270 MHz antenna. The GPR profiles allowed mapping of the lakebed and revealed hyperbolic diffractions at shallow depths, which may correspond to remnants of wooden pillars (esteios) linked to the archaeological occupation of the site around 200 AD. Some reflectors were identified just below the lakebed, while others appeared above it, possibly related to exposed structural remains or floating objects.

Introduction

The wood pillars represent archaeological evidence of pre-colonial lacustrine indigenous villages, which were supported by wooden pillars or tree trunks. These structures correspond to the prehistoric stilt houses of the Amazonian lowlands (Corrêa et al., 1991; Leite Filho, 2016; Navarro, 2013, 2017, 2018a, 2018b). These indigenous populations inhabited elevated houses constructed over rivers and lakes in the Baixada Maranhense region, whose archaeological significance has been increasingly recognized through recent discoveries. According to Navarro (2018a), archaeological remains of such places have been identified at 18 submerged sites in the estuarine zone of the Baixada Maranhense. Radiocarbon (C14) dating places these stilt-house settlements between 100 and 1000 AD, with most sites dating from 800 to 1000 AD (Navarro, 2018a). Previous surveys conducted by the Laboratory of Archaeology at the Federal University of Maranhão (LARQ-UFMA) have identified several submerged archaeological sites containing wooden pillars in the Baixada Maranhense (Navarro, 2018a, 2018b). Among these, the Coqueiro site, located in Olinda Nova do Maranhão, was selected for detailed investigation under a FAPESP-funded project (2023/16834-0) (Porsani et al, 2023, Siqueira Neto et al, 2024). This study focuses on the Coqueiro site, aiming to apply Ground Penetrating Radar (GPR) to detect submerged wooden pillars and other associated archaeological features.

Method

Ground Penetrating Radar (GPR) is a non-invasive geophysical method widely used in archaeological research due to its high-resolution imaging capabilities of buried or submerged structures, even in complex environments such as tropical floodplains (Conyers & Goodman, 1997; Sala et al., 2012; Porsani et al, 2023). In this study, GPR was applied under such conditions in order to investigate submerged archaeological features preserved beneath organic sediments in the eastern Amazon.

The GPR data acquisition was carried out between August 3rd and 17th, 2024, with a focus on Coqueiro Lake, where four days of work were dedicated. A shielded 270 MHz antenna connected to the SIR-4000 acquisition system (GSSI) was used, coupled with a Geode GPS and a handheld Garmin GPS, all mounted on a wooden boat. A total of 50 transverse profiles were acquired with an average spacing of 3 to 4 meters, along with 5 longitudinal profiles spaced approximately 8 meters apart. The choice of this acquisition grid was based on challenging field conditions, such as wind and surface waves on the lake. Data processing was conducted using the RADAN 7

Results

The GPR profile analysis revealed significant features compatible with submerged archaeological structures and geomorphological elements at the Coqueiro site. The main findings, illustrated in the four figures presented, are summarized below:

In Figure 1, the GPR survey grid over Coqueiro Lake is presented, displaying the transversal acquisition lines collected during the field campaign. Line 24 is highlighted in red, as it was selected for detailed analysis due to the presence of prominent diffractions hyperboles that may be associated with archaeological structures.

In Figure 2, between positions 950 m and 970 m, approximately six diffraction hyperbolas were identified about 15 cm below the lakebed, which in this section lies at a depth of 60 cm. These reflectors may be associated with buried wooden pillars (*esteios*), whose tops appear eroded. Considering the site's estimated occupation around 200 AD, some of these pillars may be beneath the lakebed.

In Figure 3, hyperbolic reflectors are observed between 1100 m and 1130 m, some lying directly on the lakebed, while others appear approximately 20 cm above it. In this area, the water depth reaches 70 cm. The elevation of some of these reflectors suggests the presence of partially exposed anthropogenic structures or possibly floating objects, such as vegetation, branches, or even animals.
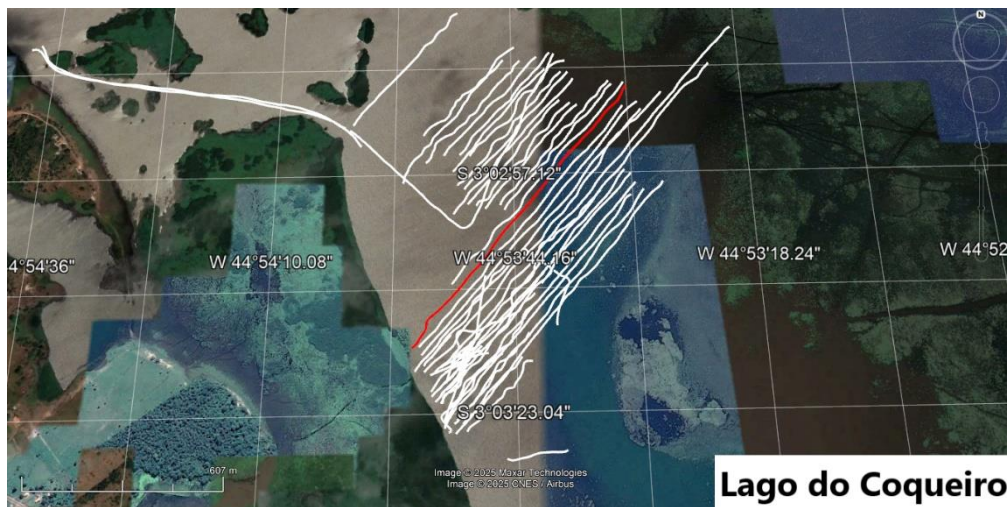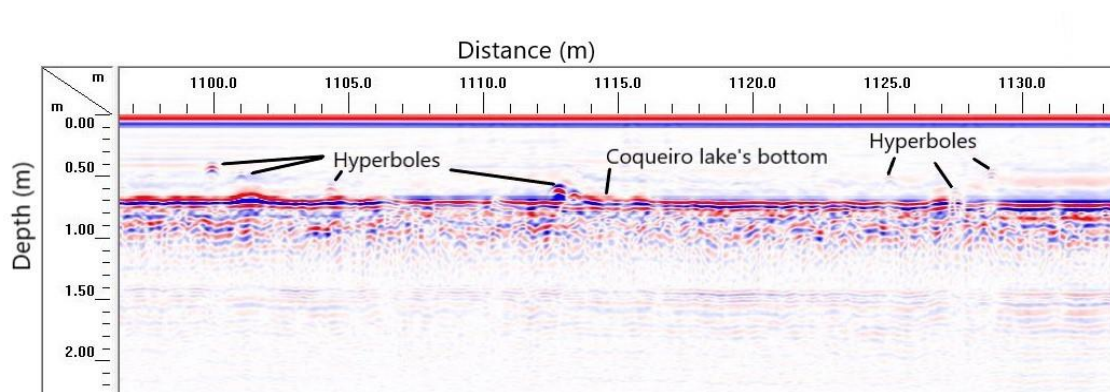

Figure 1: Survey grid showing the Ground Penetrating Radar (GPR) acquisition lines over Coqueiro Lake. Line 24 is highlighted in red.
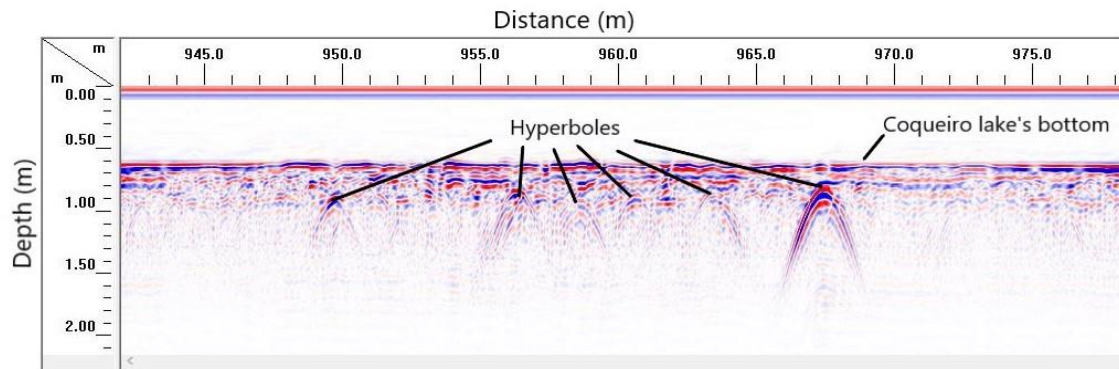
Figure 2: Radargram showing diffraction hyperbolas about 15 cm below the lakebed, possibly associated with buried wooden pillars.

Figure 3: Radargram with diffraction hyperbolas on and above the lakebed, suggesting partially exposed structures or floating objects such as vegetation or branches.

Conclusions

The geophysical investigation conducted at the submerged archaeological site of Coqueiro, using Ground Penetrating Radar (GPR), demonstrates the effectiveness of the method in detecting buried cultural features in lacustrine environments of the Baixada Maranhense. The identification of hyperbolic reflectors at or below the lakebed, some of which may correspond to remnants of wooden pillars, suggests the presence of anthropogenic structures that align with the archaeological context of the region dated to approximately 200 AD.

While only GPR was applied in this study, the results highlight its capability to detect subsurface archaeological features in submerged environments. Future investigations could benefit from the integration of additional non-invasive techniques, such as Side-Scan Sonar and bathymetry, which could complement GPR data and improve the resolution and reliability of archaeological interpretations.

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