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RESEARCH ARTICLE

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Multi-method geophysical investigation at Snow's Bend, a Mississippian platform mound

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Abstract

Archaeological investigations of Mississippian platform mounds have traditionally required invasive excavation or coring. Excavations are damaging to sites, and in many cases, invasive or destructive research methods on Native American mounds are forbidden or inappropriate. Non-invasive geophysical investigations avoid these issues but have their own challenges in terms of resolving the interior of the mound, particularly if electrically conductive materials, such as clay, are present. Here, we present a multi-method non-invasive geophysical approach using ground penetrating radar, electrical resistivity tomography, time-domain induced polarization, and electrical resistance mapping to study the Mississippian platform mound at Snow's Bend (1TU2/3), a late Moundville II/III (ca. AD 1300 to 1520) site located near Moundville, Alabama. From our data, we interpreted at least two construction stages and found indications of remnants of summit architecture on each. The final, as well as earlier, construction stage of the mound had a two-tier summit with a lower platform in the northern half of the mound. Summit buildings were identified on the lower platforms of each mound stage. We acknowledge that there is inherent uncertainty with any non-invasive approach, but demonstrate the capabilities of geophysics for new understandings of the life-histories of Mississippian platform mounds.

KEYWORDS

electrical resistivity tomography, geophysical survey, ground penetrating radar, Mississippian mound, non-invasive survey, time-domain induced polarization

1 | INTRODUCTION

Platform mounds are common monumental earthen constructions found on Mississippian sites in the US Southeast and Midwest. While such sites have traditionally been interpreted as material manifestations of hierarchy and authority, archaeological investigations of such earthworks over many decades have revealed that there is no rigid uniformity to how mounds were constructed and used. Each platform mound has its own biography and life history, with functions, uses and meanings that can vary and shift over time (e.g., Knight, 2010; Kassabaum, 2021; Lindauer & Blitz, 1997). The ubiquity and diversity of platform mounds means that studying platform mounds is "essential to understanding both long-term, widespread social patterns and important moments in the life histories of particular places" (Kassabaum, 2021, p. 24).

Platform mounds are also sacred places to the descendants of their builders, and in many cases, invasive or destructive research methods are forbidden or inappropriate. Shallow geophysical methods provide a non-invasive and more culturally sensitive means of investigation (e.g., Spivey-Faulkner, 2021; Warrick et al., 2021), although such approaches are not without their own ethical issues (Sanger & Barnett, 2021) and produce results with higher uncertainties compared with excavations.

We report on our use of multiple, non-invasive, geophysical methods to explore the life history of a platform mound located at the Snow's Bend site (1TU2/3), a Late Mississippian single-mound centre in the Moundville chiefdom in the Black Warrior River Valley, Alabama (Figure 1). Our goal is to contribute to the understanding of the history of this site by exploring the construction history of the mound, specifically examining the number of construction stages present and evidence for summit architecture.

We used a combination of ground penetrating radar (GPR), electrical resistivity tomography (ERT), and time-domain induced polarization (TDIP) to determine the stratigraphy of the mound, and we supplemented these with data from a surface electrical resistance mapping survey to identify the presence of summit architecture. Whereas most of these methods are commonly used for archaeological purposes, TDIP had limited use in archaeology and is almost unknown on North American archaeological sites (e.g., Aspinall & Lynam, 1968, 1970; Berge et al., 2019; Florsch et al., 2011; Florsch et al., 2012; Meyer et al., 2007; Schleifer et al., 2002; Zeid et al., 2016). Here, we point out the potential that this method has with modern instrumentation and processing methods, particularly as a non-destructive and non-invasive method for studying Mississippian platform mounds in the US Southeast.

2 | BACKGROUND

2.1 | Mississippian platform mounds

Earthen platform mounds in the US Southeast and Midwest are a distinct form of monumental architecture that serve a variety of roles in community building, maintenance, and daily activity. Although most commonly associated with the Mississippian period (ca. AD 950–1500), these earthworks have a deep history in the region (Kassabaum, 2019, 2021). During the Mississippian period Indigenous communities imbued these constructions with complex social meanings, histories, uses, and functions.

Traditionally, archaeologists have viewed these monumental constructions as the materialization of social differentiation, to separate the elite from the non-elite. In this view, platform mounds provide elevated surfaces for elite residences, with successive summits added over time and across generations (e.g., Knight, 2007, 2016; Mehta, 2019). Archaeologists now recognize, however, that the role of platform mounds was complex and variable beyond any presupposed rigid uniformity. For example, some mounds are thought to provide elevated ground for religious specialists and sacred ceremonies (e.g., Byers, 2013), whereas Lindauer and Blitz (1997) argue that platform mounds indicated ceremonial precincts within different communities and that the mounds accentuated social distinction in their use. Some contend that groups construct and manipulate mounds to invoke lasting impressions amongst those who interact with the architecture frequently (Brennan, 2021). Because of this diversity of use and meaning, the life histories of individual platforms need to be investigated, not presumed.

2.2 | Geophysical approaches to investigating monumental earth constructions

Geophysical methods have been extensively used to investigate monumental earthen constructions in North America and can generally be divided into two categories: Mapping methods used to non-invasively identify summit architecture and features, and tomographic methods used to identify mound stratigraphy. For the former, virtually any method appropriate for use on non-mound surfaces can also be used on mound summits, and these mapping methods typically do not resolve variations with depth. For example, King et al. (2011) used a magnetic gradiometer to map the summit of Mound A at Etowah, a Mississippian site in Georgia. This survey documented the presence of at least four summit structures, as well as the presence of additional architectural features. Similar, magnetic, methods have been highly successful at Moundville (Davis et al., 2015; Porth, 2011) and other mound sites in North America (Henry, 2011; Henry et al., 2014; Haley, 2014; Malouchos et al., 2021; Nelson, 2014). Resistance surveys (e.g., Wallis & Thompson, 2019) and GPR (e.g., Wallis &

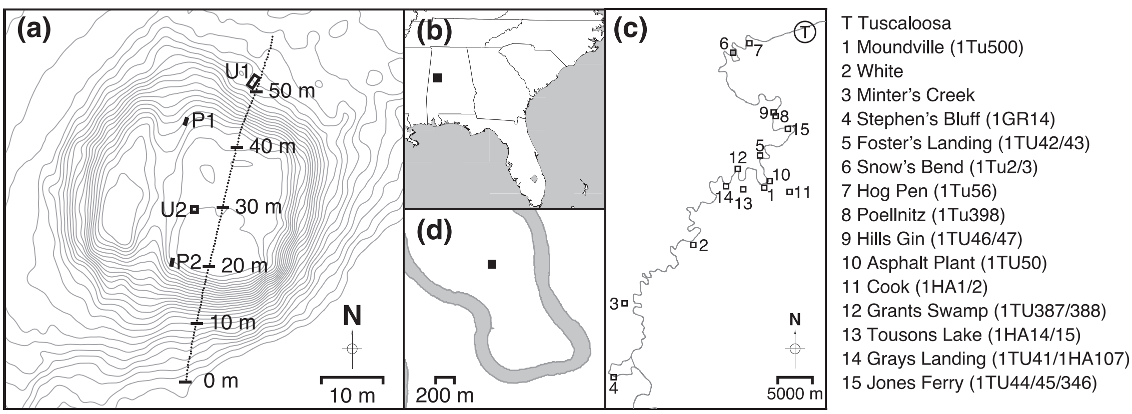

FIGURE 1 (a) Mound topography (20 cm contour spacing) and geophysical profile location (black dots). U1, U2, P1, and P2 are previously excavated units and profiles (Bozeman, 1982). (b) Site location in Alabama. (c) Other mound sites along the Black Warrior river. (d) Location of the Mound within Snow's Bend

Thompson, 2019) have also been extensively used to identify the presence of summit architecture.

More commonly, however, tomographic geophysical methods are used to explore mound stratigraphy. Putting aside some minimally invasive geophysical methods (e.g., downhole magnetic susceptibility), the most commonly used methods are GPR and ERT. GPR radargrams have been widely used to interpret mound stratigraphy, as the interfaces between construction layers and clay mantles can be identifiable depending on the attenuation of the signal and antenna used (Bigman & Seinfeld, 2017; Brannan & Bigman, 2014; Gage, 2000; Gage & Jones, 2001; Schurr et al., 2020; Seinfeld et al., 2015). For example, Seinfeld et al. (2015) used GPR to identify the internal structure of the mounds at Lake Jackson, a Mississippian site in Florida. In their investigations, they identified multiple construction episodes, the original ground surface, and possible summit architecture. ERT has also been used for investigating mound construction (Henry et al., 2014; Kassabaum et al. 2014; Monaghan & Peebles, 2010; Zimmer-Dauphinee, 2017). In the US Southeast, Kassabaum et al. (2014) used ERT, downhole magnetic susceptibility (DMS), and test excavations at Feltus, a Coles Creek site in Mississippi. Their study documents the presence of previously unknown flank midden deposits, in addition to previously identified mound surfaces, and fill zones related to mound construction. There is overlap between mapping and tomographic methods. For example, resistivity measurements can be used for mapping (in the form of resistance surveys) as well as for tomography (electrical resistivity tomography).

Mound material used in the US Southeast, often containing a substantial amount of clay, creates difficulties for GPR as well as ERT investigations. Short-wavelength GPR signals weaken substantially already at shallow depths when traveling through highly electrically conductive material (e.g., Oldenburg et al., 2021). To alleviate this issue, GPR systems with larger wavelengths can be used; however, this lowers the spatial resolution of the resulting radargram. Electrical current used for ERT travels preferentially through more conductive material and avoids more resistive material. Thus, a conductive layer (e.g., clay) on top of less-conductive material will reduce the amount of current traveling into the deeper, less-conductive material. This effect can be counteracted by increasing the length of the electrical resistivity profile, for example, by increasing the spacing between the electrodes. Unfortunately, this results in a lower spatial resolution. On the other hand, if electrically more conductive material were buried underneath electrically more resistive material, then GPR and ERT would have a higher chance to successfully image the interface between the two layers, but layers underneath the conductive layer may be obscured.

Induced polarization (IP) is similar to ERT, but instead of injecting a direct current, the method uses time-varying currents and records the time-varying subsurface electrical potential. IP data are typically collected simultaneously with ERT data. The two main types of IP are "frequency-domain IP", where the electrical current is sinusoidal and "time-domain IP" (TDIP), where a direct current abruptly shuts off and the system records the time-dependent decay of the subsurface electrical potential. Materials that have similar resistivities may react differently to time-varying currents, allowing IP to greatly improve the ability of ERT investigations to distinguish between subsurface materials. IP has been used in archaeology (e.g., Florsch et al., 2011; Florsch et al., 2012; Meyer et al., 2007; Schleifer et al., 2002; Weller et al., 2006) but is far from being a standard method. We thus provide a short introduction in Section 3.3. Because, like ERT, IP uses electrical currents, limitations of penetration remain when electrically conductive layers overlie resistive layers.

2.3 | The Snow's Bend site (1TU2/3)

Snow's Bend (1TU2/3) is a Late Moundville II (AD 1300–1400) and Moundville III (AD 1400–1520) site located along the Black Warrior River approximately 20 km north of Moundville (1TU500) (Figure 1). The site consists of a Moundville III cemetery located on the bank of the Black Warrior River and a single platform mound situated 600 m to the southwest of the cemetery. Snow's Bend was one of seven single-mound sites in Moundville's hinterlands during the Late Moundville II phase and one of eight centres in the Moundville III period (Welch, 1998). Excavations within the Snow's Bend cemetery, conducted by the Alabama Museum of Natural History in the 1930s, revealed numerous burials, many associated with artifacts and ceramic vessels dating to the Moundville III phase (DeJarnette & Peebles, 1970). Systematic surface collection of a 0.96 ha portion of the site adjacent to the cemetery conducted by the University of Michigan in 1979 yielded deposits of daub, ceramic and lithic materials, interpreted to indicate a village between the mound and cemetery (Bozeman, 1982; Welch, 1998).

The mound at Snow's Bend is four meters tall. It measures 42 m $\times$ 42 m at the base and 26 m $\times$ 27 m at the summit. Although the western portion of the mound has been disturbed by a modern bulldozed path to the summit of the mound, there are still indications that an access ramp was originally present on the northern face of the mound, and the summit was two-tiered (Bozeman, 1982; Porth, 2015, 2017).

Past investigations of the mound were of limited scope (Bozeman, 1982; Welch, 1998). Two profiles (P1 and P2) were documented along the bulldozed path, and two exploratory units (U1 and U2) were excavated (Figure 1c). Unit 2, a 1 m $\times$ 1 m excavation at the summit of the mound, revealed an upper layer of homogenous fill (Welch, 1998). Unit 1 was a 1 m $\times$ 2 m excavation at the base of the mound's northern flank. The stratigraphy in this unit (Figure 2) contained layers of daub and charcoal, as well as a posthole in one of the basal layers (Bozeman, 1982). Bozeman (1982) interpreted these findings as an indication of at least two structures on earlier mound summits.

A single radiocarbon date (Beta-1111, 940 $\pm$ 85 ^{14}C BP) run on material from late-stage mound fill was previously interpreted as being much too old for the site based on the presence of Moundville III ceramic diagnostics in the upper mound fill (Bozeman, 1982; Knight et al., 1999; Welch, 1998). Recalibration of this date using the IntCal 20 calibration curve (Reimer et al., 2020) in Calib 8.1.0 returned a calibrated date of AD 980–1270 (99%) at the two-sigma range. The latter portion of this range overlaps with the early Moundville II phase (AD 1250–1400, Steponaitis & Scarry, 2016). This might suggest that

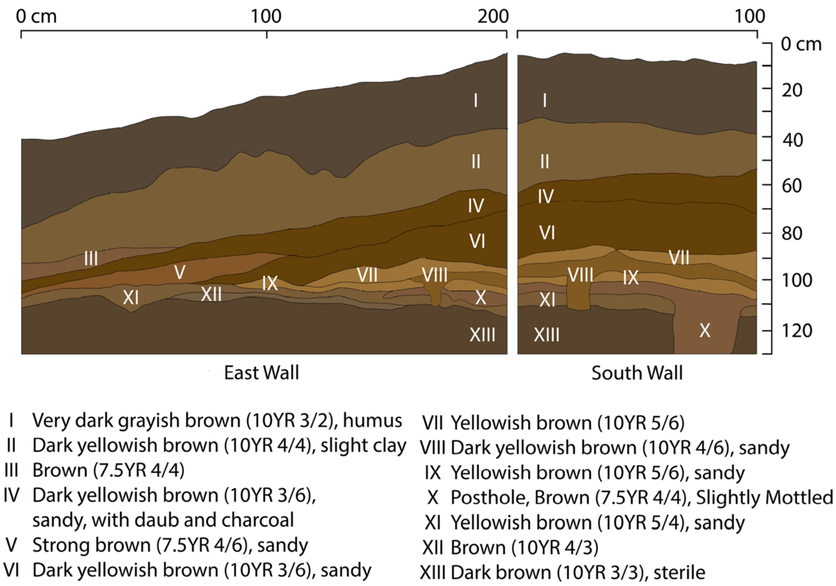

FIGURE 2 Profiles of south and east walls of Unit 1, after Bozeman (1982) [Colour figure can be viewed at wileyonlinelibrary.com]

initial construction of the mound began during the early Moundville II phase, but without additional radiocarbon dates and excavations, a single date is not sufficient the revise our current understanding of the mound's chronology.

Today, the mound is heavily overgrown with vegetation including several trees of half-meter diameter. This vegetation likely reworked the top portion of the mound. The trees are a disadvantage for GPR surveys, as they reflect the GPR signal, creating the appearance of subsurface structure in the GPR transects.

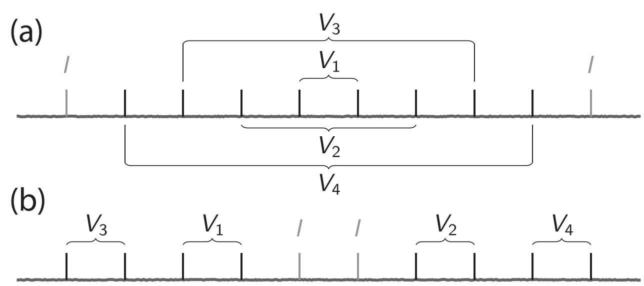

FIGURE 3 Electrode arrays used for ERT and TDIP data collection. (a) Four-channel electrode array with current electrodes bracketing the potential electrodes. (b) Four-channel dipole-dipole array

3 | METHODS

We used all three geophysical methods, GPR, ERT, and TDIP, along the same transect, crossing the mound in north-northeastern direction (Figure 1c). These data were supplemented with an electrical resistance survey of the mound summit. We had previously attempted to collect magnetic gradiometry data on the summit, but metal debris associated with a historic shed previously erected on the summit and wire fencing rendered this method useless. Comparisons of results from GPR, ERT, and TDIP surveys (Figures 5 and 6) allowed us to identify internal mound construction stages and summit architecture. In this section, we describe our acquisition strategy and equipment. For TDIP (Section 3.3), we give a more detailed explanation of the method.

For the summit electrical resistance mapping (e.g., Somers, 2006), we used a Geoscan RM-15D with a parallel-twin electrode configuration using 0.5 m sample and traverse spacing.

3.1 | Ground penetrating radar

The high clay content in the mound material made high-frequency GPR measurements impossible because the signal did not penetrate deeply enough. Instead, we use a comparatively low frequency of 100 MHz. For our measurements we paired a Sensors and Software PulseEkko 100 transmitter with a PulseEkko Ultra receiver. Additional measurements using a 200 MHz antenna did not yield useful results. Our system uses unshielded antennae. This has the advantage that the distance between transmitter and receiver can be adjusted. This allows, for example to obtain subsurface velocity information. The disadvantage of unshielded antennae is that they record reflections from objects above the surface, such as from tree trunks.

We processed the GPR data using the freely available open-source software GPRPy (Plattner, 2020). To enhance the visibility of internal boundaries (Figure 5b), we applied a high-pass filter to the raw data (Figure 5c) by subtracting a running mean for a time window of 5 ns. We also applied a t-power gain with exponent 2. The raw data together with the GPRPy processing scripts are freely available (Plattner et al., 2022).

Transforming the radar-signal arrival time into depth required us to determine a radar wave velocity. We obtained an average velocity representative of the mound material from the angle of mound-base signals (Figure 5a) as follows. We expected the mound to be constructed on a prepared level surface; thus, the GPR signal from the base on both sides of the mound should form a horizontal interface. A radar wave velocity of 0.08 m/ns led to the alignment of the base reflections underneath both flanks of the mound.

3.2 | Electrical resistivity tomography

For our ERT as well as our TDIP measurements, we used an ABEM Terrameter 2 with 48 electrodes and four channels, allowing us to record four electrical potential differences simultaneously. We used a variation of traditional ERT electrode arrays to maximize signal strength as well as using all four channels of our system efficiently. Signal strength is of particular concern for TDIP measurements as these record weak signals after current shutoff (see Section 3.3). Our first type of electrode array uses four pairs of potential electrodes bracketed by the current electrodes (Figure 3a) and is thus a parallel adaptation of the Wenner and Schlumberger array (see Loke et al., 2013, for a review). To supplement our data with additional measurements of smaller distances between current and potential electrodes, we also recorded four-channel dipole-dipole array measurements (Figure 3b).

To cover the entire mound with a high-resolution ERT and TDIP survey, we used an electrode spacing of 0.5 m and used two roll-along steps in which, after a full data collection using our 48 electrodes, we moved the first 24 electrodes along the profile (see Loke et al., 2013, for details on roll-along strategies). To complement this high-resolution survey with improved coverage at depth, we additionally collected data at 1 m electrode spacing between 7 m and 54 m along the profile. We calculated a subsurface resistivity image (Figure 6a) from the ERT data using the freely available open-source software BERT (Günther et al., 2006; Rücker et al., 2006; Rücker et al., 2017). Data and processing scripts are freely available (Plattner et al., 2022).

3.3 | Time-domain induced polarization

We collected TDIP data simultaneously with the ERT data and thus used the same electrode layout. Whereas ERT requires an electric current that does not vary with time and records the constant electric potential, TDIP abruptly shuts off the electric current (Figure 4, time = 0 s) and records the decaying electric potential (Figure 4, time > 0 s). Figure 4 shows an example of one electrical current and potential collected during our survey.

To create a spatial image of electrical potential decays at each location in the subsurface, we split the subsurface into triangular cells (Figure 6) and transformed the surface potential difference (between two electrodes) at each time step along the decay curve into a potential difference at that time step within each subsurface cell. This can be done using the same technique as ERT uses to calculate subsurface cell resistivity from potential differences at electrodes (Oldenburg & Li, 1994; Seigel, 1959). For ease of interpretation, we represent the electrical potential decay curve in each subsurface cell as a single number—the area underneath the electrical potential decay curve, normalized by the electrical potential immediately before shutoff at

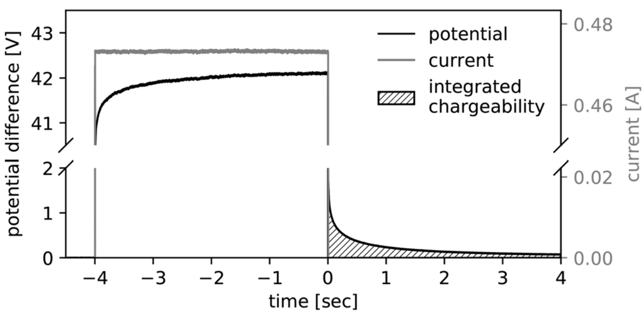

FIGURE 4 Induced polarization measurement (current electrodes at 24 m and 28.5 m, potential electrodes at 25.5 m and 27 m along the profile shown in Figure 1). Integrated chargeability is the area underneath the decaying electric potential (hatched area) divided by the potential immediately before time $t = 0$ s

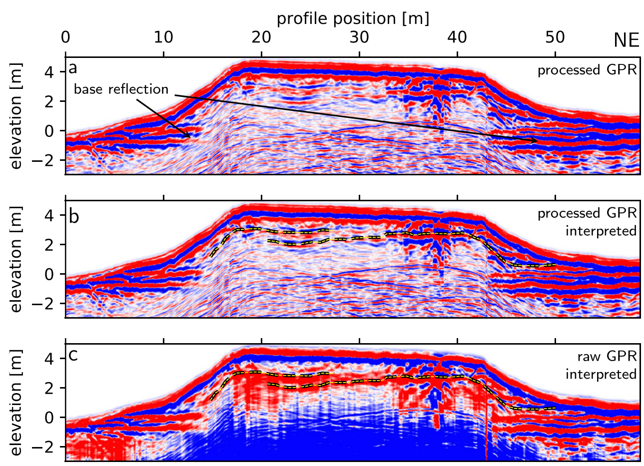

FIGURE 5 Topographically corrected GPR data using velocity 0.08 m/ns. Vertical exaggeration factor is 1.5. (a) Processed data with base reflections indicated. (b) Processed data with interpreted interfaces. (c) Raw data with interpreted interfaces. Elevation 0 m corresponds to 41 m above mean sea level [Colour figure can be viewed at wileyonlinelibrary.com]

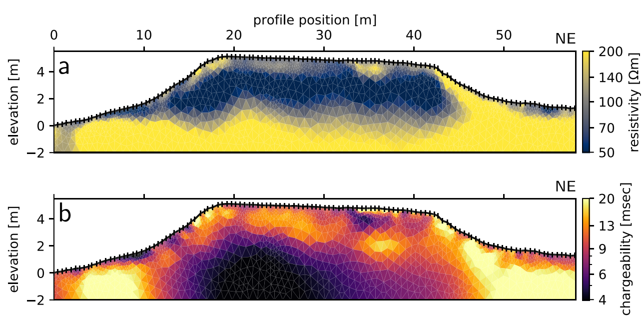

FIGURE 6 ERT and TDIP inversion results. (a) ERT inversion result. (b) TDIP inversion result showing the integrated chargeability. Elevation 0 m corresponds to 41 m above mean sea level [Colour figure can be viewed at wileyonlinelibrary.com]

time 0 s. This value, called "integrated chargeability," has unit milliseconds and describes how well the subsurface material can hold electrical charge. To avoid measurement instabilities right at the shutoff time and to avoid low signal-to-noise at late decay times, we used only the area underneath the potential decay between 10 ms and 1 s.

4 | RESULTS

4.1 | Ground penetrating radar

We observed two nearly horizontal interfaces underneath the mound's platform and two interfaces at the flanks (Figure 5b). We interpreted that the broad hyperbolic reflections deep inside the mound (Figure 5) were caused by trees on the surface. This interpretation is based on the relatively wide angle between the asymptotes of these hyperbolae, which corresponds to a radar wave velocity of 0.3 m/ns, the velocity in air. Hyperbolae from buried objects would have an angle between the asymptotes that would correspond to the radar wave velocity of the mound material. Between 34 m and 38 m along the profile, we observed a strong signal extending several meters into the mound (Figure 5). The base reflection that we used to determine the subsurface velocity (Section 3.1) is not visible between 13 m and 44 m along the profile. We interpret that this is a consequence of it being buried too deeply underneath high-loss material.

4.2 | Electrical resistivity tomography and time-domain induced polarization

In the ERT subsurface resistivity result (Figure 6a), we observed that most of the mound consisted of low-resistivity material except for an approximately 1 m-thick layer of moderately resistive material close to the surface and resistive material underneath the north-eastern flank. Between 34 m and 38 m along the profile, the resistivity image contains a resistive near-surface feature.

The TDIP subsurface result (Figure 6b) showed structure in the mound material that were not observable in the ERT results (Figure 6a). Particularly, material of high integrated chargeability is dipping downward between 28 m and 34 m along the profile and then continues horizontally. We observe two spatially confined high-chargeability features. The first one is close to the surface, between 34 m and 38 m along the profile. The second one is approximately 2 m below the surface at a similar location along the profile. The north-eastern flank of the mound also consists of high-chargeability material.

4.3 | Surface electrical resistance mapping

The surface electrical resistance map shows a prominent trough of low-resistance material at the location of the modern bulldozed trench, oriented parallel to our transect in the western part of the mound (Figure 7). Cutting our transect between profile position ~35 m and ~38 m is a rectangular feature of high resistance with a conductive interior.

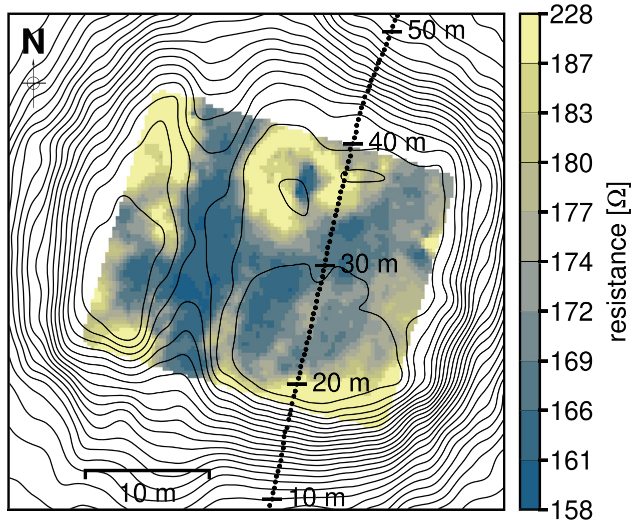

FIGURE 7 Surface electrical resistance mapping results. Dots correspond to the electrodes of the ERT and TDIP transect (Figure 6) [Colour figure can be viewed at wileyonlinelibrary.com]

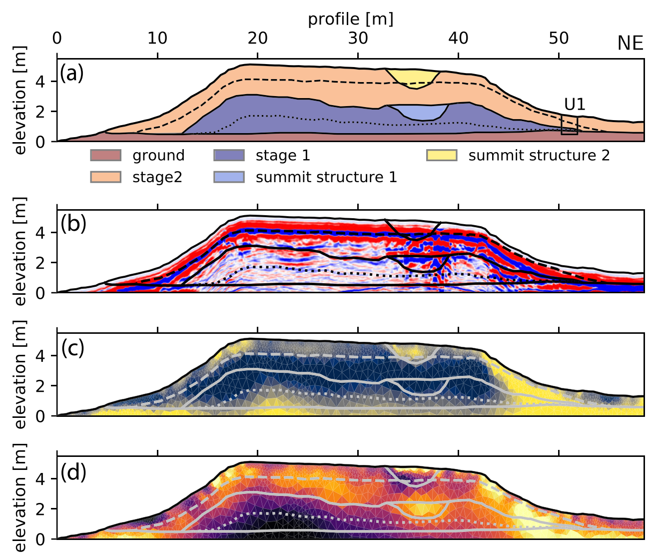

FIGURE 8 (a) Interpreted internal structure of the mound at Snow's Bend. U1 indicates the location of excavation Unit 1 (Figure 2). "Summit structure 1" is the footprint of a summit structure on mound construction stage 1. "Summit structure 2" is the footprint of a summit structure of mound construction stage 2. The dashed line indicates the bottom of a humus layer that is part of stage 2. The dotted line indicates a possible stage predating stage 1. (b, c, d) Interpreted boundaries drawn on top of (b) GPR data (Figure 5), (c) ERT result (Figure 6a) and (d) TDIP result (Figure 6b). Colour schemes and ranges for panels (c) and (d) are the same as in Figure 6a,b. Elevation 0 m corresponds to 41 m above mean sea level [Colour figure can be viewed at wileyonlinelibrary.com]

5 | INTERPRETATION

Our model for the internal structure of the mound (Figure 8a) is based on observations of GPR, ERT, and TDIP data, as well as surface resistance mapping. Of particular value was the TDIP data, which indicated structure not visible in the GPR and ERT results.

We interpret the high-resistance rectangular feature in the surface electrical resistance map intersecting our transect at position ∼35 m and ∼38 m as the outline of a building (Figure 7). We argue that this is an archaeologically significant structure for two reasons: (1) Known recent surface constructions were made of metal, which would have a lower resistance. (2) In the transect, we observe a similar structure at a similar location along the profile but buried at ∼2 m depth (Figure 8c,d). We thus interpret that both of these features (Figure 8a, summit structure 1 and 2) are remains of surface constructions and that summit structure 1 was on the surface of a previous mound stage.

To identify the topography of the summit of the earlier mound construction phase, identified through summit structure 1, we reconciled the GPR signal with the ERT and TDIP results (Figure 8b,c,d). The TDIP result showed a transition of higher to lower integrated chargeability that we reconciled with some of the GPR structure and summit structure 1. We interpret the mound below this interface as construction stage 1 (Figure 8a). From these results, we interpret that the shape of the summit of construction phase 1 exhibited a higher stage of the platform towards the southern edge of the mound and a lower stage toward the northern edge. This also reflects the shape of the modern mound summit (see the contours in Figure 1).

ERT results indicated high resistivity material covering the modern mound (Figure 8c). We interpreted this as a humus layer that was part of the most-recent construction stage and was reworked by the heavy vegetation covering the mound. This layer is not easily visible in the GPR data (Figure 8b), because the returning GPR signal at the correspondingly early arrival times is overprinted by the direct radar wave traveling from the transmitter antenna to the receiver antenna through air.

The northern flank of the mound contains high resistivity, high integrated chargeability material below the humus layer (Figure 8c,d). Excavation unit 1 identified this material as a sandy mix of daub and charcoal (Figure 2, strata IV and VI). We interpret this as debris from summit architecture that was deposited at the flank.

The posthole in Unit 1 is indicative of an earlier Mississippian structure (Figure 2). Bozeman (1982) interpreted the geometry of the posthole as indicating that it was part of a previous mound stage. Our geophysical investigation did not provide clear evidence of a stage predating stage 1, but the higher resistivity and lower integrated chargeability material close to the bottom of stage 1 could be caused by an earlier stage. We indicated this possibility, denoted by the dotted line in Figure 8a. In either case, whether constructed on the ground surface or on an earlier, unrecognized, mound construction stage, this structure would predate both summit structures evident in our geophysical data.

6 | DISCUSSION AND CONCLUSIONS

Our geophysical investigation combining GPR, ERT, TDIP, and surface electrical resistance mapping allowed us to create an image of the interior of a Mississippian mound at Snow's Bend in Alabama. In our geophysical results, we identified two construction stages, each with a location of a summit structure. Previously conducted excavations (Bozeman, 1982) indicated a potential earlier construction stage, but this could not be uniquely confirmed from our geophysical results.

Our geophysical work also provides two important insights into the history of the Snow's Bend mound. First, our results and interpretations provide evidence for continuity in the spatial location of summit architecture—with summit structure 2 being placed directly above the footprint of summit structure 1. Second, our data suggest that the two-tiered summit of the mound was not merely a small, superficial platform added as part of the final construction episode. Rather, the two-tiered form may have been part of the design of the mound from its very inception (see also Benchley, 1974). Porth (2015) previously discussed the occurrence of two-tiered mounds in the Black Warrior Valley and suggested that this was also the case for other terraced mounds in the region, including Mound E at Moundville and the White mound (1Ha7). The planning and repetition of the terraced form at Snow's Bend highlights that this form may have been meaningful and significant to its builders, rather than being a strategic response to facilitate limited mound building in the face of demographic decline during the Moundville III phase (Porth, 2015). Both of these interpretations—architectural continuity on successive summits and the planned and repeated terraced form for the Snow's Bend Mound—emphasize the long-term intentionality behind the construction of the mound and speak to the need to continue to explore the unique life histories of individual mounds.

In terms of methods, the highly electrically conductive material of the mound poses a challenge for near-surface geophysical investigations. High-frequency GPR cannot penetrate deeply enough to provide useful results, which is why we used relatively low frequencies of 100 MHz and 200 MHz. These frequencies substantially lowered our spatial resolution, but allowed us to obtain signals from deeper within the mound. Trees on the mound created additional difficulties for our GPR survey, because radar wave reflections by tree trunks created false subsurface signals. TDIP data, which we collected together with ERT data, provided some of the most decisive information for our interpretation. Magnetic mapping of the summit provided no useful results because of substantial amount of metal debris. This debris did not affect the surface resistance mapping or the GPR, ERT, or TDIP data.

Any of our methods used in a single-method approach would not have allowed us to interpret the construction stages of the mound at Snow's Bend. Multi-method surveys present an effective way of studying Mississippian mounds in a non-invasive fashion. Considering that previous excavations only marginally influenced our conclusions, we find that non-invasive geophysical investigations present a useful tool for studying the internal structure of platform mounds. This is particularly of value, because of the range of ethical issues associated with invasive excavations (e.g., Spivey-Faulkner, 2021).

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data collected for this research and open-source software scripts for processing the data are freely available from https://doi.org/10.5281/zenodo.5904290.

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